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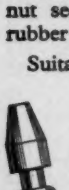

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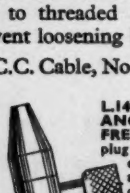

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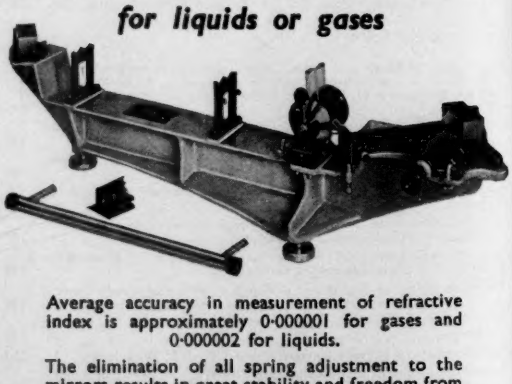

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THE STRUCTURE OF RESEARCH IN BRITAIN

IN an address on the role of government in science at the annual dinner of the Institute of Physics on March 26, Lord Hailsham expressed the opinion that many of the thorniest problems of political life would be dealt with in a more wholesome and practical way if solved by the pragmatic sanctions of technical requirements than if pursued as a doctrinal issue by *a priori* argument. While without Government support much essential scientific work would no doubt remain undone, the role of Government in science is inevitably unsatisfactory because science, a subject beyond all else jealous of its integrity, must pursue its courses without political interference.

The main theme of his address was the necessity for a close partnership between Government and science, and in discussing this question Lord Hailsham affirmed his belief that, although the risk of waste is always present in research, neither in fundamental nor in applied research are we in Britain, as a nation or as individuals, in danger of spending too much. Speaking as Lord President of the Council, Lord Hailsham claimed that the system of research councils under the Lord President places civil research in the hands of scientists themselves, and Government responsibility is discharged largely by patronage, in the old and good sense of the word, by interest, co-ordination and, to some extent, by initiative, vision and enterprise. Lord Hailsham recognized very clearly that the selection of the right projects and the decision when to extend, continue or to terminate them are the crucial problems in research, and that they demand a constant influx of young and active minds. He stressed, too, the significance of appropriate conditions if research is to be an attractive career; and he mentioned also the importance of egress as well as entry, and the value of constant cross-fertilization between research institutions and user and teaching bodies.

Lord Hailsham did not comment on the adequacy or otherwise of the Government contribution of some £225 million to the national expenditure of £300 million annually on research; he said he is convinced that, viewing scientific research simply as an investment, the industrial and private contribution could with advantage be considerably increased. He also believes that too little use is made of the published results of research. On the whole, Lord Hailsham thinks we have achieved the right balance in our administration or control of research; but, in a concluding reference to the industrial research associations, he appealed for greater interest in them by the industries they serve, and for the co-operation of the trades unions. Coupled with the indication in the subsequent report of the Council for Scientific and Industrial Research that Government policy in regard to the research associations is under review, although the Council has not yet reached final conclusions, and with some criticism of the electrical industry which Lord Hailsham made on another occasion, this has led to some speculation as to whether the Government is minded to wind up the research associations.

There are large issues involved in any such policy; but apart from this, Lord Hailsham's complacency scarcely seems justified in the light of the recent report of the Research Council (see *Nature*, June 14, p. 1623). Moreover, Dr. G. B. B. M. Sutherland's remarks as an introduction to the annual open days at the National Physical Laboratory suggest doubts as to whether, in fact, we have achieved the right balance in the organization and control of research. Dr. Sutherland emphasized the potentialities of the Government research stations, which, when well led, can and should be a jump ahead of industry. He claimed that the value of the work at the National Physical Laboratory to the national economy is at least as great as that of Harwell, but he was obviously dissatisfied with the way in which Government control is exerted. Few research projects have been terminated for lack of money, but it would appear that Treasury control has been exercised in such a way as to infringe the independence or integrity of science, which Lord Hailsham recognizes as of such outstanding importance.

In contrast to Lord Hailsham, Sir Hugh Beaver, a former chairman of the Advisory Council for Scientific and Industrial Research, in his presidential address to the Institution of Chemical Engineers on April 30, was frankly critical of the adequacy of present arrangements in Britain to make full use of the resources of science in the service of the State. Sir Hugh was concerned in this address mainly with the educational aspect and with the financing and organization of research, though he touched very briefly on the question of seeing that the results of research are both known and applied, and also on the assistance of development. The key problem is that of education, and here he showed convincingly that there is, in fact, no national policy to produce an adequate supply of scientists and technologists, or even the national organization to secure an educational policy. Even more impressive, coming from a former chairman of the Advisory Council, is the criticism of the Government structure for the organization of research, and particularly of the Department of Scientific and Industrial Research. Sir Hugh asserted that the bulk of Government research or of research sponsored by the Government does not come under the Lord President at all. Besides defence research and that on nuclear energy under the Atomic Energy Authority, any Government finance for the aircraft industry will presumably continue to come through the Ministry of Transport and Civil Aviation or the Ministry of Supply, and important research is carried out under the Ministry of Power; while the contribution of the Department of Scientific and Industrial Research to research in the universities of Britain, the recognized home of fundamental research,

now runs at half a million pounds annually, with grants to students—which might be taken as contributing something to that purpose—exceeding £800,000, compared with a recurrent grant of about £50 million provided through the University Grants Committee.

The activities of the National Research Development Corporation and of the Patent Office seem ancillary to research rather than a part of the national research effort, but in noting that the work of those bodies comes under the Board of Trade, Sir Hugh Beaver was really directing attention to the way in which responsibility for the scientific effort of the nation is distributed over numerous departments, and that the tendency to regard the Lord President as an approximation to a Minister for Science is misleading and ill-conceived. His point that no means exist either for formulating or securing a co-ordinated national policy of research or for directing the many research activities in Britain to desired ends is incontestable, and it tends to be concealed when the Lord President is made the spokesman for the scientific activities of the Government generally, even if indirectly. Further, Sir Hugh, pointing out that the Department of Scientific and Industrial Research could be described as largely a common service research department for other Government departments, remarked that there is still a wide division of opinion as to whether the various Ministries should have their own research departments or depend on the Department of Scientific and Industrial Research. The Select Committee on Estimates has sometimes been severely critical of departmental research, but the question still seems to be unresolved.

Finally, Sir Hugh Beaver suggested that by its organization the Department of Scientific and Industrial Research is virtually without a ministerial head. He did not advance any constructive suggestions here, and although his words seem to imply that the Department should be given wider responsibilities for research, he questioned whether the recent changes have made the Department suitable in form and in methods for discharging duties which its title envisages. He does not think that the Lord President of the Council is in the appropriate position to direct the scientific thinking and planning which we need to formulate a coherent policy capable of handling all the four aspects involved, namely: education, or the production of the scientists and scientific leaders; the encouragement and support of research and the allocation of research workers; the dissemination and application of the results of research; and the problems of finance. Nor does he favour the idea of a Minister of Science with such over-riding powers as the Minister of Defence possesses, even if to some extent such a Ministry would be consistent with the present position of the Ministry of Defence.

Neither Sir Hugh Beaver's address nor Lord Hailsham's speech takes us as close to the root of the matter as the discussion of scientific research in the recent survey of the organization of British central government made by a Study Group of the Royal Institute of Public Administrators, or Lord Waverley in his Romanes Lecture of 1946. Both are of value, however, as indicating certain aspects which the Council of Scientific and Industrial Research should have in mind in the survey of the work of the Department on which it is now engaged. The limitations to which Sir Hugh has directed attention should not affect the Council's consideration of the contribution of the Department to fundamental research, or the part which its own stations can play in industrial and applied research. For all those limitations, the Department is in a position to bring a wider perspective to bear than most other organizations, and to make a significant contribution towards redressing the balance of effort and avoiding duplication and waste. Moreover, Sir Hugh did not show why the responsibilities of the Lord President should not be extended in the field of science and less relevant duties curtailed, particularly if the Office were adequately and appropriately staffed.

It is clearly desirable that some means should be found for improving on the present haphazard and illogical manner in which the Government attempts to discharge its responsibilities towards science, though a completely formal and unified structure may not be the right answer. It is important, however, that, while inquiry and fresh thought as to the best and most appropriate means for ministerial responsibility and guidance to be exercised proceeds, care should be taken not to endanger the advantages which the present arrangements possess. Among those advantages the functions of the Department, in respect of both university awards and research grants and also the industrial research association system, are outstanding. However much direction at ministerial level may be improved, the value of such an independent stream of research grants will remain, and it would become even more difficult to correct weaknesses or to meet some recognized needs in university research if all Government grants for such purposes flowed to the universities in a single stream. It should be noted that the recent report of the U.S. National Science Foundation on the relations between central government and universities strongly emphasized the value of a diversity of government sources of support for university and fundamental research.

Again, while the industrial research association may not be the appropriate arrangement for every industry, and indeed in some circumstances could, by its very success, make a research association in a particular industry no longer necessary, it has become clear that the research associations in Britain are also performing very useful educational functions, quite apart from their work in furthering the dissemination of the results of research and stimulating its application. It is true that, in respect of applied research, the research association is at an inherent disadvantage compared with the research department of an individual firm; but in almost every industry there are likely to be projects which are most economically and efficiently tackled by co-operative effort. Such factors require close consideration in determining the future of the industrial research associations, and

their contribution to technical and technological education must be carefully weighed in considering the supply of scientists, technologists and technicians and the educational policy required to produce them.

It is essential, therefore, that the Council for Scientific and Industrial Research should formulate very clearly its ideas as to the exact functions of the research associations and of the Department's own research stations and institutions, and that their advantages and disadvantages should be fully discussed before any decisive change is made in the present system. It is by the appropriate use of a wide range of types of institution rather than by a rigid and formal structure that weaknesses in research are best corrected, and while it is important that every effort should be made to see that these institutions are as efficient as possible and appropriately used, it should not be forgotten that success primarily depends upon men.

This point was made by Prof. R. S. Nyholm in a recent broadcast on university research and its financial needs. After stressing the desirability of varied sources of finance, and particularly the desirability of sources of finance over and above that received from industrial organizations and research institutions, in which he referred to the value of the help received from the Department of Scientific and Industrial Research, Prof. Nyholm said that he is convinced that unless we put a much greater effort into fundamental research Britain will face serious problems in a few years time, because our position in the world twenty years hence would be determined by the fundamental research of to-day. Prof. Nyholm was particularly concerned with the calibre of the scientists whom we are losing to the United States and to other countries, partly at least because the opportunities for fundamental research, the equipment and the salaries offered are better than in Britain.

Prof. Nyholm was discussing primarily the financial aspect; but he believes that Britain can hold its best people and still attract the best from abroad if it will continue to lay emphasis upon that most precious privilege of the university, namely, freedom to do what one likes—which implies to-day the finance with which to do it. Lord Hailsham seemed to recognize this; but while the appropriateness of our whole structure for research receives examination and the relations of the different types of research institution are being reconsidered, there is much the Government could do to promote the conditions which will attract the ablest minds into research and enable them to give of their best. Nor is it simply a matter of attracting the scientist or technologist into research; it is equally important, as Sir Hugh Beaver noted, to produce scientific leaders.

This is a matter to which post-war Governments in Britain, whatever their political party, and however they may have professed their concern with the supply of scientists and technologists and their support of research, have in practice been consistently indifferent. Mr. Stanley Mayne's address to the delegate conference of the Institution of Professional Civil Servants on May 19 recapitulated some recent instances of the way in which lack of vision, clear purpose and vigorous resolution are cramping and devitalizing the scientific development of Britain. To his catalogue of examples, including the failure to make use of the Royal Ordnance factories, difficulties in connexion with aeronautical research, university finance and railway transport, and the failure of the Atomic Energy Authority to intensify recruiting and build up staff in accordance with recommendations of the Fleck Committee, could be added others, notably in the parsimony displayed towards the National Science Centre and all the projects for developing an adequate system of national lending and references libraries for science and technology.

All this obviously arises from the failure on the part of Government to appreciate the bearing of such factors on the effectiveness with which scientific work is carried out and the efficiency with which its results are made known and applied. Until genuine attention is given at Cabinet-level to the effect of society on science, the way in which obsolete forms of organization, lack of knowledge, political prejudice and the like frustrate the use of science and the development of technology, changes in the organization of the means of central direction are likely to have little effect. Decisive action by Cabinet Ministers who really understand the significance of science and technology and the conditions in which good work is done most effectively would go far to remove many of the existing hindrances, and to promote more effective use of trained man-power and other scientific and technical resources. To such matters as scientific and technical libraries might be added the control of the Patent Office, the taxation of learned societies, tax allowances for books, and questions of postage and publication, all of which can influence decisively the efficiency of communication. Such matters require no fresh forms of organization but merely people at Cabinet-level able to comprehend the issues and resolute to take the necessary action.

It is once again a matter of education, ultimately long-term but requiring also a short-term effort, if Britain is to have any real prospect of developing her scientific and technological potential. The recent report from the Council of Scientific and Industrial Research suggests that important issues of the organization and structure of research have already been raised in the Council's relation to the Agricultural Research Council and the Medical Research Council; and the Minister of Supply's recent statement on aircraft research indicates another direction in which the question of structure has assumed fresh importance. So, too, in the field of nuclear research, where not only Sir Hugh Beaver's address but also recent addresses on the development of the industry accentuate the importance of achieving an appropriate balance in the use of man-power and materials for research, and suggest doubts as to whether in fact the Council for Scientific and Industrial Research is the appropriate body to establish that balance.

Sir Hugh Beaver has rightly directed attention to weaknesses in our structure for research which merit fresh inquiry and constructive thought as a matter of urgency. Even more important, he has emphasized the close relation of the whole question of research, its organization and the provision made for its pursuit with that of education, not simply for the production of scientists and technologists, or even of the supporting technicians, upon whom the efficient use of highly trained man-power largely depends, but also of educational policy as a whole—a policy which is concerned both to produce scientists and technologists and the citizens and administrators capable of appreciating and supporting their work. The unity of education and research in relation to science and technology could not be better put. Imperative as it may be to devise appropriate arrangements for providing effective scientific and technical advice at all levels, from the Cabinet downwards, to make the fullest possible and most appropriate use of the wide range of research institutions at our disposal, to further efficient co-operation between government departments, industry, the universities and other independent research institutions, and the professional organizations of scientists and technologists, the key problem is that of education. The promotion of the expansion of scientific, technological and technical education is not enough by itself; it must be accompanied by the development of an educational system and policy which will equip men and women to live in this technological age, and will produce not simply the essential specialists but also leaders, from ministerial level downwards, aware of the human as well as the technical issues and capable of the vision and the resolution required to make full and wise use of the powers now at the command of mankind.

ADVANCES IN NUCLEAR ENGINEERING

Advances in Nuclear Engineering

Proceedings of the Second Nuclear Engineering and Science Conference held at Philadelphia. Edited by John R. Dunning and Brice R. Prentice. Vol. 1: Pp. vii+523. Vol. 2: Pp. vii+581. (London and New York: Pergamon Press, 1957.) 147*s.* net each volume.

THE International Congress on Atomic Energy held in Geneva, 1955, opened the door, closed for fifteen years, to scientific and technical information about fission and nuclear reactors. In spite of the 1,000 papers published then, there was an enormous amount of material not presented at that time, and, of course, since that time technology has proceeded apace in the many branches of applied science embraced within nuclear engineering. These volumes record the proceedings of the Second Nuclear Engineering and Science Conference held in Philadelphia, March 1957, and comprise 130 papers on reactors, fuel and a few other matters, almost all the papers being of American origin. Many of the papers amplify the Geneva subjects—such as details of the Hanford waste disposal, recovery of uranium from the Oak Ridge diffusion plant, plutonium extraction plant, etc.; many more take us forward from Geneva, such as the consideration of irradiation of liquid bismuth containing uranium, consideration of containment vessels, and the analysis of safety standards to be adopted in ships carrying reactors.

Vol. 1 opens with two papers which are interesting to read a year after they were written. A member of the U.S. Atomic Energy Commission, referring to the British nuclear energy programme based on an average cost figure of 350–400 dollars per installed kW. for the complete power stations being built by industry, remarked that these figures appeared to be materially higher than those estimated for the Yankee pressurized water reactor; alas, only in October, at the Twelfth American Assembly, the cost of the Yankee station is estimated to be more than 550 dollars/kW., and that may not include the complete power station (the Shippingport 60-MW. reactor appears to cost 1,000 dollars/kW. for the reactor portion alone). The speaker also expressed satisfaction over the fact that America had more export orders for research reactors than any other country; but is it hard to sell such reactors if the sale also includes the gift of the whole or half of the cost of uranium-235? One of the "Three Wise Men" wisely said at the Conference, "Again, Europe needs your help, but . . . our relationship will not be that of one country giving and another receiving, but of two great united nations (the U.S.A. and U.S. Europe) working in association".

Vol. 1 contains many papers on the refining of fuels, processing after irradiation, and economic consideration of fuel cycles. Some papers concern experience with the technology of reactors already in operation, others deal with the projected reactors, such as the thorium/uranium breeder reactor, the continuous removal of fission products from molten bismuth containing 0·1 per cent fuel, and a speculative paper on the economics of ceramic fuel elements operated at temperatures far higher than any fuel in operation to-day. There are many papers on pressure vessels, and pipes and other components which have to withstand high pressures or contain molten sodium, and a fairly detailed paper on the Enrico Fermi 100-MW. fast breeder reactor now being built to operate at 880° F. Almost all the large reactors now being built in America will be surrounded by a steel containment vessel of the order of 200 ft. in diameter for which there is at present no design code, and the section on plant containment is full of important information.

There is a long section on the disposal of radioactive wastes. No method now exists, says one writer, which is both cheap and permanently satisfactory. Fixation of fission products in clay is attractive, but over long periods of time it is difficult to predict the probability of water reaching the burial ground of the clay, and leaching out the long-lived elements. A Canadian paper reports some success in fixing wastes in a lime glass which would then be buried in dry ground—adding 0·1 mil/kWh. to the cost of electricity. The facilities for dealing with the wastes from the Shippingport reactor are described; here the water becomes radioactive due to corrosion and at times of maintenance is removed from the reactor but may not be dumped into the Ohio River. Ion exchange resins have been chosen, and the solution is regarded as satisfactory, simple and economical: the resin reduces non-volatile radioactivity by a factor of 1,000 and a 'gas-phase stripper'

removes activity of a further 10^6. Active resins are then stored presumably in perpetuity. Anticipated costs are not given for this treatment, although in a companion paper the capital costs are spoken of as being high.

In the section on protection and safety measures there are two papers which should be read carefully by people having responsibility for health measures in atomic plants; they concern the three basic standards of maximum permissible exposure, the last of which, dealing with total absorbed dose up to age thirty and thereafter, has only been adopted in the past year. The effect of this third recommendation is effectively to reduce the average occupational dose-rate by a further factor of 3, now to 0·1 rem/week. Dr. Lauriston Taylor's article carefully analyses the effect of these new levels on radiation control problems. An analysis of the hazards of the application of nuclear power for ship propulsion seems to show that these are distinctly greater than will be encountered with land-based stations; from a safety point of view the ship power plant ought to use low-pressure coolant, but all the submarines so far employ the pressurized water reactors operating at thousands of pounds per square inch pressure. The writer does not favour the gas-cooled reactor "when the power plant is mobile and open to collisions".

The provision of facilities for irradiating food is discussed in several papers, although no new major advance is reported on the art or science of food processing. The U.S. Army is sponsoring both electron accelerators and a γ-source (a reactor) to support research on the subject, and Brookhaven has designed a cobalt irradiator of high power. There is an interesting description of the medical research programme using the Brookhaven research reactor; the article concludes with the remark that the irradiation of diseased sites in which elements having high neutron affinity have been selectively absorbed is one of the most important uses of the reactor and is expected to remain so for a long time to come.

In Vol. 2 will be found important engineering papers on problems of some of the large power reactors such as the 175-MW. engineering test reactor at Idaho, the 20-MW. sodium-cooled reactor, the Oak Ridge homogeneous reactor which has exhibited extensive stress corrosion cracks in austenitic steel tubing and flanges, the 60-MW. breeder reactor (EBR 2) for which performance tests on individual items of construction are quoted, and the pressurized water reactors for which a considerable body of operating experience now exists. Some remarkable results on the behaviour of suspensions of uranium oxide in liquid metals are given for the first time, and there is more information on the polyphenols as possible coolants for power reactors. There are many papers on research reactors; several of our university reactor courses have fully realized the importance of instruction being given at the reactor face, and the Oak Ridge School of Reactor Technology, which has had more experience of reactor teaching than anywhere else in America, firmly advocates such teaching supplemented with reactor experimentation. In these papers will be found accounts of many experiments which can be formed on quite low-powered reactors.

There are many papers on the metallurgy of reactor constructional materials and fuels, pure and alloyed. Some results of neutron irradiation of common pure metals—non-fissionable—do not agree with Russian work reported at Geneva. The metals investigated in the Materials Testing Reactor (MTR) for three weeks hardened but did not exhibit changes in microstructure. Hanford metallurgists report on the mechanical properties of uranium after irradiation at various temperatures; the results indicate the extreme importance of optimum design of fuel elements if trouble due to distortion is to be avoided. The mechanical and anti-corrosion properties of uranium alloys with small additions of molybdenum and other elements together with ternary elements have been studied in many laboratories, but unfortunately no work is presented on irradiation damage to these alloys with the exception of one paper on pressed powder compacts of uranium and of a few of its simple alloys. It is interesting to note that even hot-pressed compacts considered at the time of Geneva to be randomly oriented have now, however, been shown to be sufficiently oriented to develop substantial dimensional changes upon irradiation, and the sintered alloy compacts swell as fast as, or faster than, unalloyed specimens. The general conclusion of several authors at the Conference was that much more work on alloys at high burn-up should be done before the best of them can be applied to reactor design.

Reactor instrumentation is a very important subject considered by one section of the Conference. One paper suggests that reactor instrumentation can now be regarded as conventional, needing only to be matched with the requirements of the reactor, but in general the papers show that many new instruments are being developed to cover a wide range of measurements. Even the common resistance thermometer has been given a new look to withstand 5,000 lb./in.^{2} for use in the pressurized water reactors. An ultrasonic flowmeter with an output signal independent of temperature of either water or of hydrocarbon fluid is one of the most original instruments described, and there are important contributions to neutron flux and positron life-time measurement. There is a strong plea put in for standardization of instruments in such a way as not to stultify the development of them, but no indication is given of what has been achieved by way of standardization to date.

The volumes are very well produced and all figures are adequate. The achievement of publication within six months of the Conference is commendable, especially as the volumes are printed and not produced by one of the modern off-set methods. The Conference has not made the mistake which I consider was made by the 1955 Geneva Congress—that of publishing the author's spoken presentation of the paper in addition to the paper, and the discussion which followed.

T. E. ALLIBONE

ANATOMY OF MATHEMATICS

A History of Mathematics

From Antiquity to the Beginning of the Nineteenth Century. By Dr. J. F. Scott. Pp. xii+266+6 plates. (London: Taylor and Francis, Ltd., 1958.) 63*s*. net.

A HISTORY of mathematics up to A.D. 1800 in 216 pages of main text can scarcely be more than an epitome. Dr. Scott spares us the trivial if amusing gossip about personalities, and concentrates on

tracing the lines of development of the subject; an appendix contains brief biographical notes on some 120 great mathematicians. But even so, there is little enough room for a comprehensive account. Dr. Scott's earlier studies have been chiefly concerned with the seventeenth century, and in his book this century occupies one-third of the main text. Consequently, some other periods receive sketchy treatment: the eighteenth century is given very little of the detailed discussion of method accorded to the previous century. If it is argued that the eighteenth century mathematicians merely exploited the creative ideas of their predecessors, the book might well have ended with the death of Newton.

The Greek period is given generous space. Dr. Scott's estimates of the debts the Greeks owed to the Egyptians and the Babylonians would not be universally accepted, and the general reader might well consult van der Waerden, "Science Awakening", for the somewhat different view presented by that great Dutch mathematician. On Greek mathematics itself, there is much useful and clear description, with comments that are sometimes misleading. For example, to remark of the parallel postulate, "It is not that anyone questions the truth of it: the important point is that it is not self-evident, as an axiom should be", after saying that "alternative geometries could be devised in which this postulate plays no part", may cause the unwary reader to suppose that non-Euclidean geometries are false. Moreover, this comment ignores the distinction drawn by the Greeks between the axiom or 'common notion' and the postulate or special assumption, which the student is asked to grant, not to accept as a 'self-evident truth'. Again, we are told that Archimedes had no idea of proceeding to a limit, but argued that if an area did not have measure k, then a contradiction must follow; this obscures the fact that for this argument to work, we must first know k, and it seems likely that Archimedes sometimes obtained k by a limit process, which was then suppressed in writing out the final synthetic demonstration.

It is with the seventeenth century that Dr. Scott gets into his full stride. His enthusiasm for the great mathematicians of that era, his wide knowledge of the material, his careful description of methods combine to provide an account which at times gives a sense of the excitement of discovery. Napier's logarithms, Descartes' marriage of algebra with geometry, Newton's binomial theorem are all most attractively described. The futile controversy between Newton and Leibniz over the invention of the calculus is briefly dismissed with the sensible remark that there is no sound reason against believing the discovery to have been made independently and more or less simultaneously. But the author is perhaps a little too generous to the forerunners, Cavalieri, Fermat, Barrow, and others; the step from their knowledge to that of Newton and Leibniz is more critical than Dr. Scott allows, and reference for a lucid and precise discussion of this point may be made to an article by Hadamard in the Royal Society's volume, "Newton Tercentenary Celebrations".

There are some excellent plates: the Rhind papyrus, pages from Barrow's "Euclid", Oughtred's "Clavis" and Stevin's "Statique", and two pages of the famous letter in which Newton describes the steps which led him to the discovery of the binomial theorem.

T. A. A. Broadbent

THE PROVINCE OF LOGIC

The Uses of Argument

By Prof. Stephen Edelston Toulmin. Pp. vii+261. (Cambridge: At the University Press, 1958.) 22*s*. 6*d*. net.

THIS book contains an interesting and provocative discussion of the philosophical issues about the nature of logic. Toulmin considers that logic traditionally has as a main object the study of argument; but, he maintains, logic has tended more and more to become a mathematical discipline the relevance of which to an understanding of the principles of argument is hard to discern. The root cause of this partial failure of logic is diagnosed as an excessive regard for the analytical type of argument found in pure mathematics combined with a desire that logic itself should have formal rigour. Logicians, therefore, have failed to see, or have neglected, the fact that most of our arguments, scientific, moral or legal, are not of this analytical type and cannot be judged valid or invalid, convincing or unconvincing, by the same criteria of logical evaluation as are the analytical arguments of mathematics. Such terms as 'valid', Toulmin holds, are general terms of evaluation, the criteria for the application of which vary systematically according to the type of argument under consideration; but formal logic has been so preoccupied with analytical argument that the criteria for the application of evaluative terms of logic to analytical arguments have been taken to be the unvarying meaning of those terms in all contexts. Toulmin considers that if we are to throw light on the nature of argument we must clearly recognize that different criteria of logical merit apply to different kinds of argument and seek to bring these criteria to light by a study of actual argument.

In his second chapter Toulmin gives an extended specimen of the kind of study of argument that he is advocating by an examination of the notion of probability. He argues very plausibly that the attempts of Carnap and Kneale to analyse the concept of probability against the background of the traditional approach to logic are unsuccessful; then, making use of a valuable distinction between improprieties and mistakes in assertions, he maintains the thesis that to say 'probably p' is to assert p (with the consequent risk of being mistaken) but to assert p *guardedly*, as is appropriate when grounds for assertion are weak, thus evading the impropriety of bald assertion in such circumstances. Toulmin maintains that this interpretation of probability is applicable even in such contexts as seem most favourable to a frequency interpretation; but it is hard to see that "The probability of throwing heads is $\frac{1}{2}$" is a guarded statement, or, if it is, what form of words one would use to make the same statement in an unguarded way.

Toulmin also offers a new schematism for the description of arguments. He recommends us to think of data, warrant and conclusion rather than of premisses and conclusion. Thus we could say that from the datum that Socrates is a man we conclude that Socrates is mortal with "All men are mortal" as our warrant; or we may conclude that Petersen is probably not a Roman Catholic from the datum that he is a Swede, with "Few Swedes are Roman Catholics" as our warrant. Toulmin argues persuasively in favour of some such redescription of argument; but it is not entirely clear what this distinction

between a warrant and a datum is: How would one know which of two universal premisses in a syllogism was datum and which warrant?

With modesty Toulmin claims to have raised problems rather than to have solved them. Anyone with an interest in the study of argument in real life, not merely in formal logicians' theorems, will find here much to interest him, something to convince him and, in all probability, something to provoke him to argument. J. O. URMSON

SUBMICROSCOPIC MORPHOLOGY

Macromolecules in Cell Structure

By Prof. A. Frey-Wyssling. (The John M. Prather Lectures, 1956.) Pp. vii+112+13 plates. (Cambridge, Mass.: Harvard University Press; London: Oxford University Press, 1957.) 40*s*. net.

THERE is evidence that the Prather Lectures on which this book is based were actually delivered at Harvard in 1955, which, in a subject that is advancing so rapidly, detracts a little from a presentation in 1957, but it will none the less be warmly welcomed by the numerous admirers of Prof. A. Frey-Wyssling's pioneer researches and earlier contributions to the literature. It is a handsome little book, and the electron micrographs especially, on which so much of the argument depends, are very well reproduced.

The emphasis and the topics chosen are naturally mostly botanical—the fine-structure of starch grains and chloroplasts, and the fine-structure, growth, and differentiation of plant-cell walls—but a necessary wider background also is provided by a chapter on "Macromolecules in the Cytoplasm". The approach throughout, as is to be expected in a set of special lectures of this kind, is distinctly personal, and this extends to many of the references and some of the text-figures. For example (p. 1): "I have called this new field of investigation *Submicroscopic morphology*. In the early days we used polarizing microscopy for this research (Ambronn and Frey, 1926), but soon X-ray diffractometry brought welcome support (Frey-Wyssling 1937*a*), and since 1944 electron microscopy (Frey-Wyssling and Mühlethaler 1944, 1946) has raised submicroscopic morphology to a generally recognised standard science". Such historical over-condensations are in the cause of saving space, but newcomers might misconstrue them, I am afraid.

Though Prof. Frey-Wyssling's favoured technique these days is electron microscopy, of which he has made most valuable use, he concedes that the older methods of polarizing microscopy and X-ray analysis are "still useful" (p. 5), and indeed ranges over and seeks to co-ordinate all kinds of information, as the reader will find to his ever-widening profit. There is no narrow way of looking at the structure of biological tissues, and no shallow way either. We continue uncovering finer and finer constituents, but the picture appears still much the same in the depths. Prof. Frey-Wyssling makes this point repeatedly, as when, for example, he remarks, "this special architecture must be the result of the morphogenetic work of the cytoplasm. Mere mechanical considerations cannot explain the inception of any differentiation" (p. 36); and "The bordered pits are a beautiful example of the morphogenetic capacity of the cytoplasm" (p. 48); and as regards the cytoplasm itself, so optically empty no longer ago than the early 'thirties, I particularly like his summarizing comment: "As a result of this discussion we find that the term cytoplasm is defined by the negative property of comprising that fraction of the living substance that escapes our morphological analysis" (p. 71).

I would commend, too—out of so many other points of agreement or controversy that one could raise without the least difficulty in so rich a field—his discussion of the corpuscle–fibre paradox and related questions. Man-made fibres, invented on the basis of tricks picked up primarily from Nature's workshops, are spun from more or less drawn-out chain-molecules, yet it turns out now that Nature herself seems to proceed more often than not by first stringing together unit packets of coiled and folded chains.

There are a few misprints and anomalies in spelling and grammar, and I must confess to having been peculiarly saddened to read 'flagellae' four times over. W. T. ASTBURY

A KEY TO LEAF-MINING INSECTS

Bestimmungstabellen der Blattminen von Europa

Einschliesslich des Mettelmeerbeckens und der Kanarischen Inseln. Von Prof. Erich M. Hering. Band 1: Pflanzengattungen A-L. Erzeuger Nr. 1—3133. Pp. 648. Band 2: Pflanzengattungen M-Z. Erzeuger Nr. 3134—5551. Pp. 535. Band 3: Neubeschreibungen von Minen-Erzeugern Systematische Übersicht der Wirtspflanzen und der Minen-Erzeuger. Abbildungen. Pp. 221 (86 tafeln). (The Hague: Dr. W. Junk, 1957.) Complete set, three volumes, 180 guilders. [About £18.]

LEAF-MINING insects feed on plant leaves, not by biting pieces out of them (like most caterpillars) but by destroying either the pallisade tissue or the spongy parenchyma, or both. The 'mines' are of very diverse forms, and are often characteristic of the species of insect which causes them. As a rule the damage, though unsightly, and such as to impair the efficiency of the leaf as a functional organ, is of little economic significance. However, some crops may, from time to time, be seriously damaged, so the group is potentially dangerous. Thus the mangold fly, whose larvæ can usually be found in any field mining the leaves of sugar beet, often does little damage to the crop, but it may cause losses exceeding three tons per acre. Agricultural and horticultural entomologists often find leaf-mining insects or observe the damage they cause, but identification of the insects often presents serious problems. Coleoptera, Hymenoptera, Lepidoptera and Diptera all have species with the leaf-mining habit, but this habit may be confined to one member of a family, and similar damage may be caused by widely separated species of insects.

In the first two of the volumes here considered the various host plants are listed alphabetically, and there is then given for each plant a key listing all the mining insects, with a brief description of the damage they cause. The author has interpreted his subject rather liberally, so some insects which might be considered as gall producers are listed here as miners, but this adds rather than detracts from the value of the book to most users. 5551 instances of mining damage are listed. The keys are well and simply laid out, so those who do not read German easily should be able to use them without difficulty.

Vol. 3 lists and describes a dozen new species of leaf-mining Diptera, and one new lepidopteran. It includes a list of the food plants, and of the families of insects involved. 170 pages contain 725 line drawings, mainly featuring the damage caused to plants by these insects. The figures are quite well drawn and reproduced.

These volumes will be a useful tool to agricultural entomologists and others, but it is a pity they could not have been produced more cheaply. The printing and paper are good but the books are poorly bound in flimsy paper covers. Notwithstanding the usefulness of the contents they seem expensive at eighteen pounds for the set of three modest volumes.

KENNETH MELLANBY

TRAINING MANAGERS

New Ways in Management Training

A Technical College Develops its Services to Industry. By Cyril Sofer and Geoffrey Hutton. Pp. xii+127. (London: Tavistock Publications, Ltd., 1958.) 15*s*. net.

CONCERN to make his department of more value to industry in the training of managers led Robert Harcourt, head of the Department of Management and Production Engineering at the Brunel College of Technology, to initiate the study which is described in this book. The objects of the study were to examine the function and possibilities of a department of management and production engineering in servicing industry, how industry could make known its wants and needs as well as the way industry could help the department. The task was entrusted to the Tavistock Institute of Human Relations and, in collaboration with members of the Brunel College staff, was carried out during 1954–56.

While their report on this valuable investigation will be of interest to their fellow social scientists, Sofer and Hutton's account is likely to be of more direct value to training officers, educational administrators and many industrial managers. It will be of even greater relevance to those responsible for the control and development of technical colleges.

To set the study in its right background, an account is given of the place of the technical college in the national educational system and its place *vis-à-vis* the universities and other organizations in the training of management for industry. This is followed by details of the kinds of students who attend management courses at technical colleges, together with reasons as to why they attend. These are sometimes illuminating. Most of those who were studying for management certificates, for example, saw their courses as in some way a contribution to their personal advancement; most of the management students expected to get better jobs with employers other than their own. Few students had really high ambitions and a not infrequent comment was: "I don't think I'll ever get to director level because you need social connections for that. Somebody who is likely to finish up at that level would not have come from a technical college, but would have taken a Cambridge degree".

One of the great weaknesses of technical college classes is borne out by the finding that most students did not expect to find discussions with fellow students very helpful to learning. Each student's contact with others was said to be minimal: "Hardly any friendships were developed within the class and very little discussion of course material took place spontaneously. . . . At the end of the evening everybody went home—they were tired and hungry".

The attitudes of firms in Acton to technical colleges and their staffs can be regarded as typical for the whole of Great Britain. Although educational and scientific pursuits rank fairly high as social activities in Britain, the status of technical colleges among them is low; they are thought to serve a less-important purpose than more 'academic' institutions, and to be concerned more with training in specific craft skills than with the preparation of young people for life or for positions of social leadership and responsibility. Teachers in technical colleges are regarded more as school teachers than university lecturers, and as persons of mediocre calibre. The technical college teacher was thought to be insufficiently appreciative of production management, 'up in the air' and over-theoretical; it was often said that a man who really knew management and could practise what he preached would be a manager, not a teacher. Larger firms felt no need for the services of management and production engineering departments except for a limited amount of junior supervisory classes and for management courses of the conventional type; smaller firms made demands for courses in the organization and supervision of production and in general education.

The rest of the book describes how Sofer and Hutton and their collaborators attempted to find a way through this wall of prejudice. After considerable resentment had been dissipated, the teachers began to understand that the views of the industrialists were not wholly distorted; the industrialists began to realize that under their noses was a most valuable service if they cared to use and contribute to it. Detailed surveys were carried out in firms to show how the department could be of greater value to them and, eventually, separate advisory panels were formed to make a permanent link between the College and industry. Finally, members of the Tavistock Institute of Human Relations were asked to organize a course to help the teachers to become more expert in dealing with students from industry and industrial affairs. It needs little reading between the lines to appreciate that this was far from successful and that the approach of the academic social scientist in teaching teachers has considerable limitations.

Of the study as a whole, not much need be written. Harcourt and all those concerned at the Brunel College of Technology deserve applause for their courage and perspicacity in initiating the project. The Tavistock Institute of Human Relations should be congratulated for the way it saw and grasped an opportunity to improve the quality of management education at Acton and elsewhere. Sofer and Hutton are to be warmly commended for carrying out a difficult survey in an objective and discerning manner and for recording it so intelligibly. This is so out of keeping with other publications of the Tavistock Institute that it scarcely seems possible that this book could have been produced under its auspices. By this important work Sofer and Hutton have not only made a contribution to the development of better management education at technical colleges, but may also have reconverted leading industrialists to the belief that the Tavistock Institute really has a contribution to make to the solution of many industrial problems.

T. H. HAWKINS

La Lutte contre *Stephanoderes hampei* Ferr.

Par G. Schmitz et P. Crisinel. (Série Scientifique, No. 70.) Pp. 156. (Bruxelles: Institut National pour l'Étude Agronomique du Congo Belge, 1957.) 130 Belgian francs.

THE coffee berry borer beetle, *Stephanoderes hampei*, is one of the important pests of a tropical crop, and its control by insecticides has been reconsidered since the development of chlorinated hydrocarbons and organic phosphorus compounds. Primarily a pest of *robusta* coffee, this small Scolytid was introduced into South America and the East Indies in early consignments of seed from tropical Africa. It causes shedding of the developing coffee cherry and damage to the bean.

Schmitz and Crisinel give the results obtained between 1950 and 1955 in controlling *Stephanoderes* on a field scale in the north-east of the Belgian Congo. Trials were carried out with a number of chemicals, including DDT, BHC, dieldrin and parathion. These were applied in a wide variety of ways from hand dusting and spraying to power-operated machines. The best results under prevailing local conditions were obtained with an endrin emulsion and a power-operated atomizer, 'Swissatom 2000', for which operating costs are given in detail.

The fact that successful pest control depends on a thorough knowledge of the pest is recognized by the authors, who devote nearly half their paper to establishing the background against which they had to work. A historical survey of *Stephanoderes* as a pest of coffee, supported by a detailed bibliography, is followed by an account of its life-history, and by a statement of the problem from the point of view of coffee production. The whole problem of 'shedding' as found in plantations in Uele is discussed in relation to the proper diagnosis of the part played by *Stephanoderes vis-à-vis* fungus attack and physiological disturbance of the coffee bush.

The Institut National pour l'Étude Agronomique du Congo Belge and the Compagnie Cotonnière Congolaise are to be congratulated in collaborating in establishing this work on so wide a basis. Schmitz and Crisinel have, in consequence, produced a report which will be of great value to those interested in the wide field of crop protection in the tropics.

W. V. HARRIS

Chromatographic Techniques

Clinical and Biochemical Applications. By Dr. Ivor Smith. Pp. xiii+309. (London: William Heinemann Medical Books, Ltd., 1958.) 45*s*. net.

THIS is rather different from the general run of books on this subject. It is confined mainly to the application of paper chromatography to substances of clinical interest. No attempt is made to cover the innumerable methods; instead, one single apparatus for one- and two-dimensional separations is described and a minimal number of solvent systems and location reagents of proved usefulness have been selected. Opening chapters deal with apparatus and give a full account of the methods of desalting and preparing fluids for chromatography. Chapters then follow, each devoted to recommended procedures for preparing chromatograms of amino-acids, sugars, barbiturates, indoles, steroids, phenolic acids and so on, in human blood, urine and tissue fluids. Some of these chapters include very useful sections on clinical interpretations of chromatograms in disease. Final chapters give guidance for further investigations of unknown constituents observed on chromatograms and describe model experiments for students. The uniform style of the chapters reflects careful editorship and close collaboration with the various authors. The result is an attractive book, which within its limits contains a tremendous amount of information most attractively presented; it should prove of the greatest value for research workers in clinical chemistry, and because it has sought to standardize methods it should stimulate the wider adoption of paper chromatography for routine clinical chemical purposes and even encourage the general practitioner to use the method.

R. CONSDEN

Stedman's Medical Dictionary

Edited by Norman Burke Taylor in collaboration with Lieut.-Col. Allen Ellsworth Taylor. Nineteenth revised edition. Pp. xlvi+1656. (London: Baillière, Tindall and Cox, Ltd., 1957.) 88*s*.

THIS weighty volume provides brief definitions of many thousands of medical, dental, veterinary, chemical and botanical terms, together with notes on their derivation and pronunciation. Short biographical sketches of outstanding figures in medical history are included. A separate, 36-page section on medical etymology precedes the main work, and this most informative contribution should be of the highest value to medical students unversed in Greek and Latin. An appendix contains, among other useful data, comparative tables of weights and measures, temperature and barometric scales, and anatomical nomenclatures.

The dictionary itself satisfies the essential requirement of any medical dictionary, that it be reasonably comprehensive, accurate and lucid. It is not free from mistakes and misleading statements; on p. 787 "splenomedullary" leukæmia is described as the commonest form of leukæmia, with marked leucocytosis, "large uninuclear eosinophile myelocytes predominating"; acute leukæmia is not listed as such; under "hemoglobin" only three abnormal forms are mentioned; and in many minor respects definitions are sometimes not in keeping with current beliefs. Blemishes of this sort are inevitable in so massive a work, and are, of course, confined chiefly to subjects in which medical advance has been rapid. A more serious drawback for the British reader is the American spelling, regrettably often different from that used in this country, which renders the dictionary unsuitable for use by medical secretaries and typists.

F. G. J. HAYHOE

Observations on Birds of Southeastern Brazil

By Margaret H. Mitchell. Pp. x+258+11 plates. (Toronto: University of Toronto Press; London: Oxford University Press, 1957. Published for the Division of Zoology and Palæontology, Royal Ontario Museum.) 45*s*. net.

THE birds of South America and their taxonomy are very well known; very little has been recorded on what the birds look like and how they behave in their natural surroundings, and what these surroundings are. This book is a valuable collection of field observations on 289 species occurring in south-eastern Brazil. The author resided in Rio de Janeiro for four years and had opportunities of visiting the adjacent States. Field identifications were checked against specimens in the São Paulo State Museum and with the aid of Dr. Olivério Pinto. Although mainly concerned with field study, Mrs. Mitchell did not neglect to become conversant with relevant literature and the text is annotated with more than 100 references. The style is pleasantly informal and very easy to read.

MEASUREMENT OF THE ENERGY SPECTRUM OF PROTONS EMITTED FROM THE FUSION REACTION IN SCEPTRE III

By W. M. JONES, A. C. L. BARNARD, S. E. HUNT and D. R. CHICK
Research Laboratory, Associated Electrical Industries, Ltd., Aldermaston, Berks

DEUTERIUM fusion may proceed by two reactions, D(dp)^{3}H and D(dn)^{3}He, which occur with almost equal probability at low deuteron energies. Measurements on the energy spectrum of the neutrons emitted from ZETA have already been reported[1], but no measurements of proton energy have yet been reported from fusion reactions occurring in gaseous discharge systems.

If fusion is induced by deuterons having only thermal motion, the energy spectrum of the protons will be independent of the angle of observation, whereas if some process producing a preferred direction in the deuteron motion is involved, the proton energy will depend on the angle of observation with respect to the preferred direction of motion.

The present communication describes a preliminary investigation of the proton spectra from Sceptre[2] using cameras with nuclear emulsion plates inserted into the torus. The cameras protruded only slightly inside the walls of the torus and did not produce any measurable fall in the externally measured yield of neutrons, so that their presence did not appear to modify the discharge mechanism. They were arranged to accept protons emitted at nominal angles of 30°, 90° and 150° to the direction of flow of positive gas current. In order to prevent surface fogging of the plate due to low-energy radiation and light from the discharge, it was necessary to protect the plates by thin copper-foil windows.

The proton energies were estimated using the range–energy relationship for protons in Ilford $C2$ emulsion[3], a correction being applied for the loss of energy in the copper foil[4]. The measured dip angles and the theoretical shrinkage factor were used in deducing the range. Additional exposures were made at 90° using a camera of better geometrical definition, with which the angle of entry into the emulsion was known directly from the geometry. This permitted more precise absolute measurements to be made of the proton energies at 90°. The mean energy of this proton group was 3·03 ± 0·02 MeV., which shows that the protons originated in the (d–d) fusion reaction.

The proton yield estimated from the track density and camera geometry was consistent with the neutron yield estimated by external liquid scintillation counters. From the direction of the proton tracks in the 90° plates, it could

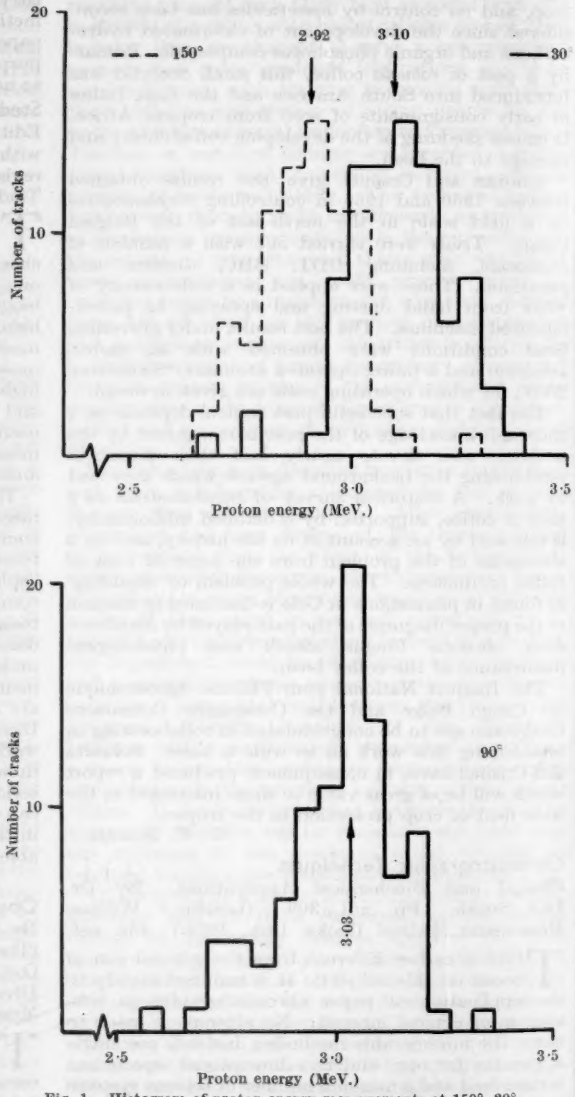

Fig. 1. Histogram of proton energy measurements at 150°, 30° and 90° to direction of positive gas current flow

Table 1. TORUS : SCEPTRE III

Date of exposure	No. of discharges	Deuterium pressure in torus	Condenser voltage (kV.)	B_z field (gauss)	No. of primary turns	Peak torus gas current (k.amp.)	Angle of observation	No. of proton tracks measured	Mean energy of proton group	Standard deviation	Estimated total error
31/5/58	4,477	1·4μ	25	500	16	100	30°	44	3·11	0·02	±0·03
16/6/58	5,000	1·4μ	25	500	16	100	30°	40	3·10	0·02	±0·03
20/5/58	7,980	1·4μ	25	500	16	100	90°	93	3·03	0·02	±0·02
11/6/58	5,900	1·4μ	25	500	16	100	150°	36	2·94	0·02	±0·04
15/6/58	5,000	1·4μ	25	500	16	100	150°	20	2·91	0·03	±0·04
17/6/58	5,400	1·4μ	25	500	16	100	150°	22	2·90	0·03	±0·05

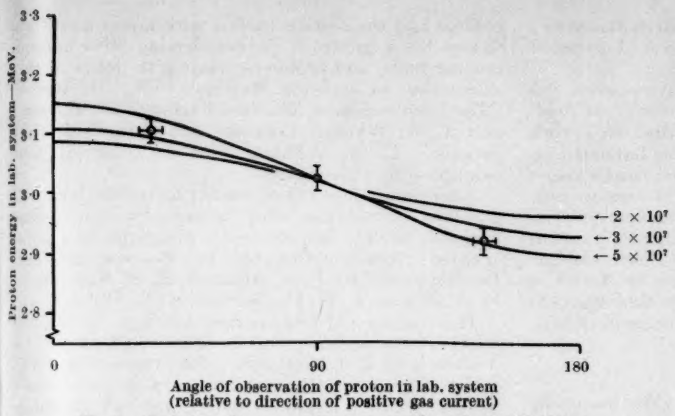

Fig. 2. Variation of mean proton energy with angle of observation

be deduced that most of these originated from the centre (one-third or one-half) of the discharge tube.

Energy spectra obtained at 30°, 90° and 150° are shown in Fig. 1. The energy values obtained for the three angles of observation are given in Table 1, together with the conditions under which the exposures were made. The errors were obtained by combining the statistical standard deviations with the errors associated with measurements of foil thickness and possible slight differences in density between the emulsions used in the measurements.

The results indicate that the majority of protons observed originate from fusion between deuterons the centre of mass of which has a velocity component in the direction of positive gas current flow. In Fig. 2 the observed variation of proton energy is plotted and compared with that calculated for deuteron centre-of-mass velocities of 2×10^7, 3×10^7 and 5×10^7 cm. sec.$^{-1}$ relative to the laboratory. The results give the best fit for a centre-of-mass velocity of about 4×10^7 cm. sec.$^{-1}$. This is less than the velocity of centre of mass indicated by the published results for ZETA[1].

We wish to thank the members of the Thermonuclear Section of this Laboratory and Mr. E. D. Taylor for their assistance in the experimental work, and Misses S. J. May and O. V. Lake, who scanned the plates. Thanks are also due to Dr. T. E. Allibone for his great interest and encouragement in this work and for permission to publish these results. The work has been supported in part by an Atomic Energy Research Establishment contract for thermonuclear research.

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PEACEFUL USES OF ATOMIC ENERGY

SYMPOSIUM IN AUSTRALIA, 1958

A SYMPOSIUM on "The Peaceful Uses of Atomic Energy" was held in Sydney during June 2–6, organized by the Australian Atomic Energy Commission, the Australian universities, and a number of Australian industrial organizations.

The symposium was a major success and, in its stimulation of thought on matters related to atomic energy among all sections of the community in Australia, exceeded the hopes of even the most optimistic of its initiators. Several reasons have emerged for these results. The Australian Atomic Energy Commission's high-flux research reactor at Lucas Heights became divergent earlier in the year (see *Nature*, May 24, p. 1433); radiochemical and other laboratories have been commissioned and are being made ready to examine the products of the reactor when it is taken in some months time to its full power of 10 MW. Australian universities have introduced, or are considering, postgraduate courses in nuclear engineering and science. There has been a general increase in the tempo of nuclear research in universities, spreading from nuclear physics to other disciplines. Formal arrangements with the universities of Australia for their use of the facilities of the Lucas Heights Research Establishment have been made by the formation of the Australian Institute of Science and Nuclear Engineering. Under the stimulant of the Commission's isotopes advisory service, Australian industry has taken a rapidly increasing interest in the immediate applications of atomic energy. In the mining area, the uranium oxide production plants in Rum Jungle and Radium Hill are in full production, and the large plant at Mary Kathleen started production during the symposium.

With this background of atomic energy developments in Australia, a total of 435 delegates, including 38 from overseas, came to the symposium to discuss a total of 114 papers. The overseas delegates from the United Kingdom, the United States, Canada, France, New Zealand and Pakistan, particularly those countries well advanced in atomic energy developments, provided an energetic complement to the Australian contributions.

A considerable interest was displayed by the general public of Australia. A comprehensive atomic energy exhibition featuring displays from Australia and other participating overseas countries was well attended by members of the public. Prof. M. L. E. Oliphant's lecture to 2,500 school children was so popular that it had to be given in two sessions. A number of leading overseas scientists gave addresses on the radio and to scientific societies. Vigorous public questionnaire sessions from forums of local and overseas scientists were arranged as both 'live theatre' and television sessions.

The symposium was divided into five sessions: Section 1, Materials; Section 2, Power Engineering;

Section 3, Power Auxiliaries and Research Reactors; Section 4, Basic Sciences; and Section 5, Associated Techniques.

A period during the last day of the symposium was devoted to developments in the thermonuclear field. Dr. T. E. Allibone described the gas-discharge work at Harwell and at the A.E.I. Research Laboratories at Aldermaston. Dr. W. H. Pennington read a paper by Dr. A. E. Ruark describing the American programme. Prof. Oliphant discussed proposed experiments in Australia with the Canberra homopolar generator. These developments in thermonuclear experiments were of particular interest to Australia in that they gave a full account of the achievements and difficulties in this only recently declassified field.

Materials

The papers on materials can be divided naturally into two groups. The first dealt with minerals and ores containing uranium and thorium, with their occurrence in various parts of Australia, and with the several plants now operating for their extraction. The second group was concerned with actual or potential reactor materials, with their preparation and fabrication, and their properties.

In the first group there were papers dealing with the distribution of minerals important for atomic energy in South Australia (W. Johnson), in the Northern Territory (B. P. Walpole), in New South Wales (E. O. Rayner), and in Queensland (J. H. Brooks). These papers gave an up-to-date picture of the known deposits of ores of uranium and thorium in these States, with a good deal of information on the geology of the areas concerned.

One paper dealt with the instrumentation problems of the search for uranium and thorium (J. Daly and D. F. Urquhart). This covered the design of equipment for assaying and for prospecting, the latter use presenting the main problems. Equipment for use in moving vehicles and for bore logging, based on Australian experience, was described.

Australia's main uranium-producing plants were the subject of several papers. The production of uranium concentrate at Rum Jungle was described by Baker, and the somewhat different processes used at Radium Hill were described in two papers, the first (T. A. Rodgers) dealing with ore production and physical concentration, while the second (J. N. Arnold) dealt with the chemical extraction of uranium, and its recovery by ion exchange methods from the physical concentrates. A fourth paper (R. A. Couche and F. R. Hartley) gave a detailed account of the processes worked out for the recovery of uranium from the Mary Kathleen ores in Queensland. These papers brought out the differences in behaviour of the ores at these plants, all of which produce oxide concentrate of roughly the same type.

An important paper in this group was that entitled "The Jigged-Bed Ion Exchange Pilot Plant for Uranium Extraction", by G. L. Herwig, R. M. Stewart, E. A. Swinton and D. E. Weiss. It describes the plant and operating results, when extracting uranium from an acid pulp of low filtering properties, using a continuous ion-exchange process which does not require the pulp to be filtered. The process was used to treat experimentally one of the more difficult Rum Jungle ores.

The other half of this materials section consisted of nineteen papers. Australian interest in the development of the high-temperature gas-cooled reactor and the reactor fuelled with liquid metal was shown by a group of papers dealing with ceramic nuclear fuels, and problems relating to liquid metals. "Ceramics as Reactor Materials" (K. D. Reeve), "The Preparation of Thorium Carbide" (D. E. Scaife and A. W. Wylie), "Ceramics and Cermets Investigations" (L. S. Williams and J. Graham) were examples of such papers.

A considerable study of reactor materials, including graphite, zirconium and aluminium alloys and uranium dioxide fuel elements, was given in a paper entitled "Recent Progress in Reactor Materials Development" by F. N. Albaugh, R. E. Nightingale, E. A. Evans, J. W. Riches and R. L. Dillon.

The commercial process now adopted for the production of uranium metal in the United States was described by F. L. Cuthbert. The stages of leaching, solvent extraction, the production of 'green salt' and its reduction to uranium metal were all described. This paper also described the casting and machining or uranium and its alloys, and the recovery of the metal from process scrap.

On the technology of liquid metals, a paper by F. L. Bett was concerned with compatibility studies between liquid sodium and niobium, and a paper by H. M. Finniston dealt with corrosion in liquid-metal systems. This paper discussed the mechanism and kinetics of mass transfer in solid metal – liquid metal systems, such as may be encountered in reactors fuelled with liquid metal.

Other papers in this group dealt with the production of uranium metal powder by a hydriding process (J. W. Kelly), with the production of uranium metal powder by reduction with calcium of uranium oxide (R. H. Myers and R. G. Robins) and with the production of uranium metal powder by electrolysis (R. G. Canning). B. C. Woodfine presented a study of the materials problems in producing fuel cans for gas-cooled reactors, operating at higher temperatures than are used at present. He dealt with the magnesium alloys which are now favoured, and went on to discuss beryllium, carbon and stainless steel for this purpose.

The miscellaneous part of this section included papers on fusion welding of reactive metals (J. M. Newburn), irradiation effects on uranium and its alloys (H. M. Finniston), levitation heating (B. Harris, E. G. Price and A. E. Jenkins), neutron diffraction studies of compacts (T. M. Sabine and K. D. Reeve), materials for control of reactors (W. J. Wright and K. P. Nicholson) and studies of the lower halides of niobium and zirconium (I. E. Newnham).

The meetings of the materials section were marked by lively discussion throughout.

Nuclear Power Programmes

Section 2 covered papers on national atomic power programmes, specific power-reactor developments, and some papers on the economic questions that might be raised in the development of atomic power in Australia.

Five papers were presented on the national development of atomic power. They were: "The Nuclear Power Programme in the U.K." (H. H. Gott); "Development of Nuclear Power in the U.S.A." (L. H. Roddis); "The Canadian Nuclear Power Programme" (D. G. Hurst); "French Private Industry in the Atomic Field" (P. M. C. Retourna); "Possible Developments in Nuclear Fuel Cycles in Australia" (J. P. Baxter and C. N. Watson-Munro).

H. H. Gott's paper dealt briefly with the United Kingdom programme of installation of graphite-moderated natural uranium power reactors using carbon dioxide cooling. He discussed the advances that are taking place in the design and the development of these reactors and pointed out that the United Kingdom would only change to a significantly different type of reactor design if a new reactor could with considerable certainty generate power at a lower cost than those under construction.

P. M. C. Retourna outlined the contributions of French private industry to the French graphite-moderated natural uranium power reactors using gas cooling, and to the subsidiary industries such as graphite, calcium and zirconium production, chemical extraction and processing plant.

The extensive United States programme of reactor experiments, demonstration power reactors and full-scale power reactors was described by L. H. Roddis. He outlined the breadth of the American research and development programme in pressurized-water reactors, boiling-water reactors, sodium – graphite reactors, fast-breeder reactors, aqueous homogeneous reactors, organic moderated reactors, liquid-metal fuel and molten-plutonium systems and gas-cooled reactors.

D. G. Hurst outlined the programme of development of heavy-water natural uranium reactors in Canada and described the nuclear-power demonstration reactor under construction at Des Joachims. He described the conceptual design features of a 200-MW. (electrical) reactor under consideration by Atomic Energy of Canada, Ltd., in conjunction with the Hydro-Electric Power Commission of Ontario.

J. P. Baxter and C. N. Watson-Munro stressed the need for nationally integrated fuel cycles in Australia. Based on a number of speculative assumptions of nuclear power requirements, proportions of natural uranium and enriched reactor systems, they made some estimates of the order of requirements of Australia's needs of fertile and fissile materials during the next four decades.

The four papers on specific power reactor developments from the large British nuclear consortia, namely, "Medium Output Gas-cooled, Graphite-moderated Reactors for Australia", by A. L. Shaw (A.E.I.), "Engineering Aspects of Nuclear Power Stations employing Gas-cooled, Graphite-moderated Reactors", by K. J. Wootton (General Electric Co.), "Design of the Gas-cooled, graphite-moderated Reactor for Power Production", by R. D. Vaughan (Nuclear Power Plant Co.), and "The Hinkley Point Reactors", by Dr. H. S. Arms, C. Bottrell and P. H. N. Wolff (English Electric Co.), provided a great deal of interest.

These firms have recently given tenders in the United Kingdom for a total of about 1,400 MW. of electrical capacity, and construction work has begun on all four nuclear power stations. As one speaker put it, "The British Electrical Industry had not established a reputation as a charitable institution", and it was obvious from the papers and from the subsequent discussions that these reactor designs represented a 'down to earth' approach to the problems of providing a significant and reliable contribution to the British electricity grid. All four gave broad descriptions of current designs and discussed the areas in which improvements and reductions of cost could be achieved. Two of the papers discussed possible applications of this type of reactor to Australian conditions, and some estimates of costs—both current and futuristic—were given for reactors ranging from 60 MW. upwards.

J. M. Harrer delivered a paper entitled "Operational Data and Experience from the Experimental Boiling-water Reactor". In this paper he detailed the actual operating experience obtained over a period of twelve months with this reactor; during this period no major technical fault had developed and the claims of compactness, simplicity, safety, reliability and convenience had been substantiated.

Two papers discussing the possibilities of the reactor systems under investigation by the Australian Atomic Energy Commission Research Establishment were presented. They were: "Gas-cooled Reactors of a Mixed-fuel Moderator Type", by G. C. J. Dalton, and "Liquid-metal Fuel Reactors", by K. F. Alder. Both these reactor systems have a number of possibilities of choice of moderator, fuel diluent and coolant, but neither has yet reached the stage of a reactor experiment.

Three papers on economic questions in the development of nuclear power in Australia were presented: "The Growth in Demand for Electricity in Australia", by the Australian Department of National Development; "Atomic Power in Australia—some Economic Consideration", by the Commonwealth Bank Discussion Group; and "The Economics of Electricity Generation in Queensland and the Potential Employment of Nuclear Reactors", by R. D. Waldie.

The paper by the Department of National Development, from an examination of the relationship of growth-rates of population, real national *per capita* income, energy consumption and electrical-energy consumption, made some estimates of the growth-rates of Australian electricity demand for the next four decades.

The paper by the Commonwealth Bank examined the impact that the installation of nuclear plant of high capital cost would have on the capital demands of a rapidly developing country such as Australia. That by R. D. Waldie discussed the possible application of nuclear power to the widely separated electrical networks in the large State of Queensland and came to the conclusion that the Mt. Isa mining area offers the best possibilities.

Power Auxiliaries

This section covered research reactors, chemical processing, waste disposal and problems of power generation.

Five papers on research reactors were presented: "Canadian Research Reactors", by D. G. Hurst; "The Design and Construction of HIFAR", by W. H. Roberts; "The Control and Instrumentation of the Reactor HIFAR", by G. Page; "The First Year of Operation of DIDO", by F. W. Fenning; and "An Industrial Research Reactor", by T. E. Allibone, D. R. Chick and A. J. Salmon.

The paper by D. G. Hurst was a valuable one, particularly as Canada has had as much experience as any other country in the world in the operation of high-flux research reactors. F. W. Fenning's paper was particularly useful to Australia; except for some minor modifications described by W. H. Roberts, the Australian reactor HIFAR is a copy of DIDO, and the British experience will be invaluable in considering its operation.

The paper on the A.E.I. pool-type research reactor, presented by T. E. Allibone, evoked considerable

interest as an example of an industrial firm constructing a research reactor of relatively low cost with neutron fluxes remaining close to 10^{14} neutrons per cm.^{2} per sec.

The four papers presented in the sub-section on power generation were: "Nuclear Steam-power Plant for Waterless Zones", by W. R. Wootton; "Similitude in Gas Turbines for Nuclear Power Plants", by G. G. McDonald; "Nuclear Power Reactor and Turbo-alternator Interaction under Dynamic Conditions", by H. K. Messerle and J. F. Armstrong; and "Heat Transfer in Homogeneous Gas-cooled Reactors", by G. de Vahl Davis.

The first of these was of particular interest to Australia in that it detailed a conceptual design and cost estimate of a 30-MW. (electrical) PIPPA type reactor, employing a sealed air-condenser.

Three papers on chemical processing were presented: "Chemical Reprocessing of Irradiated Fuels", by J. E. Cole; "The Future of Nuclear Fuel Processing in Australia", by G. L. Miles; and "Acid Leaching and Anodic Dissolution of Graphite-moderated Fuels", by K. R. Hyde, D. J. O'Connor and J. L. Woodhead.

J. E. Cole gave a brief survey of American practice in processing plants and gave a cost estimate of a plant capable of processing 10 tons a day of irradiated natural uranium. A number of questions were posed by Australian members of the audience on the design and economics of smaller plants. Some estimates of the likely requirements of chemical processing in Australia and of the possible kinds of plant that might be used were given by G. L. Miles.

The two papers on the treatment of waste, "Philosophy and Practice of Radioactive Waste Disposal", by R. B. Temple, and "Handling, Treatment and Disposal of Radioactive Wastes", by J. A. Lieberman, provided some lively discussion both on and off the symposium floor. It became obvious that a world appreciably powered by fission energy would need to retain control over the storage of fission products and could not allow uncontrolled disposal in the sea or elsewhere.

Basic Sciences

This section contained a wide variety of papers divisible broadly into theoretical physics, cosmic rays, reactor physics, radiation and nuclear chemistry.

The papers in theoretical physics, while of limited direct interest to the practical application of atomic energy, gave some basic scientific stimulation to the symposium. They were as follows: "Optical Treatment of Inelastic Scattering", by S. T. Butler, N. Austern and C. Pearson; "The Ground-state of the Triton; Effect of Repulsive Core Forces", by J. Blatt and G. Derrick; "The Ground-state of the Triton: Group Theoretical Classification of Wave Function", by G. Derrick and J. Blatt; and "Nuclear Forces at Very Small Distances", by S. T. Ma.

The same general remarks apply to the papers on cosmic rays, though in this case a number of papers had computing and instrumental techniques of special interest in the field of nuclear reactor research. The papers were as follows: "The Sydney Air Shower Experiment": (1) "The Experimental Apparatus", by D. D. Miller; (2) "The Determination of the Radial Distribution of Electrons and the Size Spectrum of Extensive Air Showers", by C. S. Wallace; (3) "The Zenith Angle Distribution of Air Showers", by J. Malos; (4) "The Radial Distributions of High-energy Nuclear-active Particles and of μ-Mesons in Cosmic-ray Air Showers", by J. A. Lehane.

Papers in the field of reactor physics and reactor theory were: "Some Recent Developments in the Theory of Doppler Broadening of Nuclear Resonance Regions", by J. L. Cook; "On the Second Order Terms in the Age Theory of Neutron Distribution", by L. C. Woods; "The HIFAR Oscillator", by K. P. Nicholson and A. W. Pryor; and "Neutron Diffraction on HIFAR", by T. M. Sabine. Whereas the first two of these contributed to existing reactor theory, the last two papers described specific instruments under construction for use with the Australian HIFAR reactor.

A wide range of papers was presented in the field of radiation, nuclear chemistry and chemistry, as can be seen by the following titles: "The Chemistry of Positronium", by J. W. Lee and J. H. Green; "Radiochemical Method for the Detection of Fast Neutrons", by R. Mills; "Free Radical Measurements in the Radiolysis of Liquid Hydrocarbons", by K. H. Napier and J. H. Green; "The Chemical Fate of a Radioactive Atom", by D. L. Baulch and J. F. Duncan; "Distribution Studies and Stereospecificity in Recoil Tritium-labelling of Organic Compounds", by W. G. Brown and J. L. Garnett; "The Chemical Fate of Recoiling Fission Fragments", by D. Hall; "The Solution of Lime in Liquid Calcium and its effect on the Reducing Properties of the Metal", by D. J. M. Bevan and F. D. Richardson; "The Oxidation of Particles of Uranium Dioxide", by J. S. Anderson; and "Imperfections induced in Solids by Fast-particle Irradiation", by P. G. Klemens.

These papers ranged from fundamental studies to applications outside the field of chemistry such as the paper by R. Mills on the use of the $^{56}Fe(n,p)^{56}Mn$ reaction as a threshold detector of fast neutrons.

Associated Techniques

Twenty-eight papers were presented in this section, covering a large number of topics between which there was little close relationship.

One group dealt with radioactive isotopes, the techniques of their use and their applications in various fields. A survey of the use of radioisotopes in Australia was presented by J. N. Gregory. He showed that the number of shipments of isotopes per million of the population is substantially less in Australia than in the United Kingdom, America or New Zealand. The use of isotopes is now expanding more rapidly, and with the prospect of supplies from Australia's new reactor rapid development of uses in future may be expected.

The medical uses of isotopes provided eight papers: "Evidence for a Direct Mechanism in Leukæmogenesis", by P. L. T. Ilbury; "Beta-ray Therapy with Strontium-90 Sources", by D. F. Robertson; "The Effect of Ionizing Radiation on the Synthesis of Porphyrins by the Red Blood Cells of the Domestic Fowl", by R. Tirrell; "Experimental Hæmatology using Iron-59 and Chromium-51", by I. Brading, E. P. George and R. J. Walsh; "Inaccuracy of the Colloidal Gold Method for determining Liver Blood Flow", by J. McRae, M. Playoust, R. Boden and C. R. B. Blackburn; "Localization of the Placenta using Radioisotopes", by E. P. George and D. McGrath; "Use of Radioactive Tracers in Cardiac Investigations", by E. P. George, J. Hickie, F. A. Rocke and W. A. Seldon; and "Radioiodine Studies of the Equilibrium Turnover of Thyroxine in the

Thyroid Gland", by T. H. Oddie and I. D. Thomas. All were from Australian sources and show the increasing interest in medical circles in the use of these substances.

J. Carpenter and J. S. Gladstones discussed the production of mutants induced by radiation in subterranean clover and lupins in Western Australia. Some mutants of possible commercial value have been produced and are being examined.

In a paper entitled "Analytical Chemistry in Atomic Energy", L. E. Smythe described some of the requirements for analytical work in this field. He discussed the uses of automatic coulometry, square-wave polarography, gamma-spectrometry, low-background beta-counting, infra-red spectrometry, mass-spectrometry, emission spectrography, X-ray spectrography and vacuum fusion analysis, in an analytical laboratory serving an atomic energy research establishment.

G. L. Miles and D. F. Sangster presented a detailed account of the facilities for radiochemical work at the Lucas Heights establishment of the Australian Atomic Energy Commission. They described the special facilities for working with high levels of radioactivity, the ventilation requirements and methods adopted to prevent the spread of radioactive contamination.

A comprehensive account was given by H. M. Finniston of the radioactive handling facilities at Harwell for metallurgical work with both alpha- and gamma-active materials. The paper described at some length the special problems of working with plutonium, and the ways in which complicated metallurgical procedures can be carried out while adequate protection is ensured. The problems of working with high levels of gamma-activity were also described, together with the techniques developed at Harwell for this type of work. D. Campbell Allen contributed a paper on "High Density Concrete for Radiation Shielding".

In the instrumentation group, papers were presented on "Some Temperature Effects of Geiger–Müller Tubes", by R. E. Belin; "A General Purpose Wide-range Electrometer", by C. T. Murray; and "Transistor Decade Scaling Circuits", by R. E. Aitchison.

The use of radioactive isotopes in connexion with measurement of the water content of soils was discussed by J. W. Holmes; and J. S. Watt and K. R. Lawther described the attenuation of gamma-radiation as a means of measuring the density of a slurry of tungsten powder and water moving in a pipe. B. J. J. McHugh and H. E. Booth presented a paper on the gamma-ray measurement of defects in poles and trees; cæsium-137 was used as the source of gamma-radiation and results were given on the detection of cavities, damage by white ants, and other defects, in this way.

In the chemical research field, a paper was presented on "The Diffusion of Hydrogen Sulphide Gas through Surface Films on Water" (J. G. Hawke), in which sulphur-35 was used. D. R. Llewellyn and A. L. Odell gave a paper entitled "The Use of the Isotopes Oxygen-18, Carbon-13 and Carbon-14 in the Study of the Exchange Reactions of the *tris*-Oxalato Chromium III Anion".

The only paper in the symposium on educational methods was delivered in this section. It was "Programme of Education for Nuclear Engineering and Science at the N.S.W. University of Technology", by L. C. Wood and J. H. Green. This paper described the Institute of Nuclear Engineering, which was established in this University in 1954 and which has developed during the past four years not only a substantial research programme in the University but also postgraduate courses in various branches of nuclear engineering and science. These are the only courses of this kind at present available in Australia.

J. P. Baxter
C. N. Watson-Munro

MIGRATIONAL DRIFT OF BIRDS PLOTTED BY RADAR

By Dr. DAVID LACK, F.R.S.

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IT has long been known that land birds which normally migrate north-east – south-west across the main European land mass appear on the east coast of Britain with easterly winds, but rarely under other conditions[1]. Ritchie[2] showed precisely that differences in the point at which waxwings (*Bombycilla garrulus*) arrived on the British coast on different days were explicable if their courses were the resultant between their heading in a constant direction and the wind at the time. Williamson[3] made a systematic study of the appearance of migrant land birds off their normal route, showed that such migrational drift was common, and defined the types of weather which determine it, but differed from other authors in regarding it as "essentially a down-wind movement". He also considered it as occurring primarily in night migrants. The behaviour of migrants in a cross-wind is of special interest in view of experiments showing that migrants can head in a fixed direction by day if they see the Sun[4], and by night if they can see the stars[5], and that displaced birds can 'home' apparently through a sense of geographical position which depends on the Sun[4,6].

The course of migrant birds over the sea can now be removed from the realms of inference, since the 1-MW. 10-cm. early-warning radar sets of the Royal Air Force detect small birds to ranges exceeding 60 miles (Tedd and Lack, in the press). The following information concerning directions of flight has been summarized ahead of a detailed study, in view of the continuing research by others on both drift migration and bird navigation. Personal observations of migration on a radar plan-position display in Norfolk from March 29 until April 18, 1958, were supplemented by photographs of the same display, made available by the Research Branch, Fighter Command, taken about once an hour from March 15 until April 21, 1956, and four times a minute from February 24 until April 20, 1957, a few days being missed in both years. Hence there are records from Norfolk for

three successive years covering the main departure period of the land-birds wintering in England, of which the commonest are starling (*Sturnus vulgaris*), blackbird (*Turdus merula*), redwing (*T. musicus*) and chaffinch (*Fringilla coelebs*), with various other less common species, mostly passerines. These birds set off in March and April from the east coast of England over the North Sea on their way to more northerly breeding grounds.

In the period studied, the echoes from migrant birds were usually commonest soon after it was fully dark, with a subsidiary peak soon after sunrise. The volume of migration was assessed from the density of the echoes, and the directions of movement from the after-glow, which shows previous positions of each echo. At any one time, the directions were usually spread over about 45°, sometimes more, and their mean was estimated by eye to the nearest compass point, except that when two points were almost equally favoured both were cited, while when the movement was nearly due east, care was taken to see whether it was, on average, slightly north or slightly south of east. Such estimates were made twice daily, in the evening well after dark, and soon after sunrise, usually over some two hours in each period. The speed and direction of the wind were taken from the figures for Hemsby, Norfolk, in the Daily Aerological Record of the Meteorological Office, which was the nearest available point to the sea area studied.

Williamson (ref. 3, p. 185) wrote that "lack of wind is believed to be the external factor stimulating the act of migration". Table 1 shows clearly the deterrent effect of strong wind, since scarcely any large migratory movements occurred when the surface wind exceeded 15 knots at night and 10 knots by day. The direction of the wind had little influence, Table 2 showing that large migrations occurred, by night and day, with winds in every quarter. There seemed to be a slight tendency, especially by day, to favour following winds and to avoid head winds; but nearly all the large movements occurred during cross-winds, which, in the prevailing anticyclonic conditions, were usually from the north-east or south-east, that is, partly opposed to the direction of travel.

Table 1. Wind-speed and Volume of Migration

Speed at surface (knots)	After dark		After dawn	
	No. of days on which migration was:			
	small or none	large	small or none	large
0–5	4	9	12	9
6–10	10	37	22	17
11–15	11	20	22	6
16–20	15	4	12	3
21–27	4	0	2	0
Total	44	70	70	35

Notes: (i) Radar records for most days and nights March 15–April 21, 1956, February 24–April 20, 1957, and March 29–April 18, 1958; (ii) the surface wind was recorded at Hemsby, Norfolk, at respectively 2000 and 0500 hr. in 1956 and March 1957, and at 1700 and 0800 hr. in April 1957 and 1958.

Table 2. Wind-direction and Volume of Migration

Direction of surface wind	After dark		After dawn	
	No. of occasions when migration was:			
	small or none	large	small or none	large
Following (260°–280°)	0	2	1	5
Partly following (200°–250°, 290°–340°)	5	11	4	7
Cross (170°–190°, 350°–010°)	5	18	7	7
Partly opposed (220°–070°, 110°–160°)	8	27	7	7
Opposed (080°–100°)	3	3	4	2

Notes: (i) Winds recorded at Hemsby, as noted in Table 1; (ii) all occasions were omitted in which the wind was less than 6 knots, and also those with a small migration in which the wind was more than 15 knots by night and more than 10 knots by day.

Table 3. Direction of Wind at 900 m. and Direction of Migration

Mean direction of bird migration in North Sea	No. of occasions on which direction from which wind blew at 900 m. at Hemsby was:							
	East	Southerly			West	Northerly		
	080–100	110–160	170–190	200–250	260–280	290–340	350–010	020–070
After dark								
N.N.E.		1						
N.E.	1	6	6	3				
N.E.–E.N.E.		3	3	1	1			
E.N.E.	2	5	2	6	4	1		
E.N.E.–E.					6	1	1	1
E.		1			2	1	4	4
E.–E.S.E.						1	3	
E.S.E.				1		3	5	3
E.S.E.–S.E.								1
S.E.						1	1	7
After dawn								
N.E.		6	2	2				
N.E.–E.N.E.		1	2	1				
E.N.E.		2	2	4	1			
E.N.E.–E.			1	2	2	2		
E.	1	1	1		3	6	1	1
E.–E.S.E.				1		3	1	1
E.S.E.		1				2	2	3
E.S.E.–S.E.							1	3
S.E.						1	1	2
S.S.E.								2

Note: Directions were usually spread over about 45°, sometimes more. The mean was estimated by eye, whenever possible to one of the main compass directions. Two directions are joined, for example, N.E.–E.N.E., when there were about an equal number of each on the occasion concerned.

The evidence from radar height-finders and other sources indicates that most of the migrants were travelling between 2,000 and 4,000 ft. above sea-level; hence for analysing the influence of the wind on the directions taken, the figures for the wind at 900 m. were used, and these, in fact, gave smoother results than those for the wind at the surface or at 1,500 m. Using only the direction of the wind (wind-strength will be analysed later) Table 3 suffices to show that the course taken, both by night and by day, is the resultant between a more or less constant heading (probably slightly north of east) and the wind at the time. On almost every occasion when the wind (at Hemsby) had a southerly component, the migrants over the sea travelled on a course north of east, and on almost every occasion when the wind at Hemsby had a northerly component, they travelled on a course south of east. Further, nearly all the few apparent exceptions to this statement in Table 3 are readily explicable, since they occurred when there was a marked shift in the direction of the wind at Hemsby, either in the course of the period in question, or between the surface and 900 m.; while in a few cases when the birds travelled a little north of east with a northerly wind, the wind was very light. Hence, these findings fully support Ritchie's view that the course taken by drifted migrants is the resultant between the heading of the birds and the wind, and they also confirm that migrational drift is exceedingly common, since it occurred almost every day and every night, and there was no difference between the day and the night in its frequency or nature.

This evidence indicates that, when over the sea, the migrants maintained a constant heading by means of their sense of direction (based on the position of the Sun or the stars), but that they did not at all correct for wind drift by that more mysterious capacity by which they 'home'. Their course from

Norfolk varied between north-east and south-east, sometimes on successive nights, so that, according to the night on which they happened to travel, the migrants might make their landfall anywhere between mid-Denmark and Belgium, some 400 miles apart. It is at this juncture, presumably, that their sense of geographical position comes into play. That birds possess such a capacity is shown not only by homing experiments[4,6] but also by the fact that various drifted migrants trapped and ringed in Britain have later been recovered in their normal Continental wintering or breeding grounds well to the east, and Williamson has rightly stressed the importance of such re-directed movements. Indeed, it may be claimed that the homing sense, now demonstrated in many species of birds, is primarily an adaptation to counteract drift, which the present observations show to be a normal accompaniment of migration.

The observations in Table 3 refer to directions over the sea. Many fewer directions were observed over the land in Norfolk, but these followed the same general trends, the birds travelling south of east with northerly winds and north of east with southerly winds. Hence migrational drift also occurs over the land, though if the birds fly lower when over the land than over the sea, their drift will be smaller, since the wind is normally weaker nearer the ground. These remarks, it should be added, refer only to those migrants flying high enough over the land to be detected by radar, and not to those flying low by day, which may follow the coast or other 'guiding lines'.

While, as shown here, migrational drift is regular in fine or moderately fine weather, Williamson and others have found that drifted migrants land in large numbers at the British east-coast bird observatories primarily when they must have met wholly overcast conditions during the course of their journey. Under such conditions, birds can no longer see to navigate by the Sun or stars. Moreover, as is well known, they do not normally set off on their migrations in such weather, hence the spring departure from Norfolk normally provides unsuitable conditions for studying what happens. However, in clear weather on the afternoon of April 17, 1958, many redwings and other species took off rather north of east, and soon after dark, mist and rain became general. Rain echoes came to obscure most of the plan-position display, but one gap remained well out to sea, and here, between 2030 and 2130 hr., I had quite unusual difficulty in establishing the directions of the birds from the afterglow of the echoes. In one period, for example, there seemed to be twenty-one directions scattered fairly evenly between north-north-east and south-east, and eleven others between south-south-west and north-north-west; but the afterglow was normally short, and soon afterwards the directions often seemed to have changed. Yet only three hours earlier, in fine weather, there were many sustained tracks in a nearly constant direction north of east, and the same applied once more when the rain cleared off in the early morning. Presumably, during the period of fully overcast conditions, the birds could not maintain their heading, and flew around irregularly with repeated changes of direction.

It is hoped to study such conditions more fully later; but provisionally the radar evidence suggests that migrants meeting fully overcast skies over the sea fly around irregularly and indecisively, in which case their eventual direction will be that of the wind at the time. Further, they are likely under these conditions to become extremely tired, and so will tend to alight at the first land encountered. With normal drift in fine weather, on the other hand, migrants reaching the coast seem usually to proceed some way farther before settling, and so are not concentrated at the point of arrival. Hence it is primarily when migrants meet overcast conditions that they later appear in large numbers at the British bird observatories.

I am extremely grateful to the Air Ministry and to the Research Branch, Fighter Command, for allowing me full facilities for this work, and to Mr. W. G. Harper, of the Meteorological Office, East Hill, who is also working on birds and radar[7], for most helpful discussions. The pioneer work in this field of E. Sutter[8] was an invaluable spur.

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OBITUARIES

Prof. C. H. Desch, F.R.S.

No one could come in contact with Cecil Henry Desch, who died on June 19 at the age of eighty-four, without being influenced by his astounding knowledge and complete sincerity. Educated at Birkbeck School, Finsbury Technical College and University College, London, as a chemist, he then went to Würzburg, where he obtained his doctorate.

After being connected with the brewery and cement industries for a short time, he joined the Metallurgical Department of King's College, London, in 1902, and it was during this time that much of the work on his book on "Metallography" was done. In the preparation of this volume he was greatly indebted to Mrs. Desch for the preparation of the beautiful microsections with which it was illustrated. The influence of this book on English metallurgy was immense. In many ways it broke new ground, and it may be that this represents his greatest influence on metallurgical science, in any event in Great Britain.

In 1909, Desch was appointed to the Graham Young lectureship in metallurgical chemistry in the University of Glasgow, remaining there until the end of the First World War, when he was appointed to the chair of metallurgy at the Royal Technical College in that city. His tenure of this chair was short (1918–20), and on the retirement of Arnold he succeeded him in the chair of metallurgy in the University of Sheffield. His twelve years in this chair saw immense changes and the beginning of the modernization which was inevitable if its reputation was to be maintained, and it was during this time that I knew him best. It was not an easy job to follow Arnold and to make the changes in the existing course which Desch saw to be essential, and those in closest scientific contact with

him must have wondered whether this post was really congenial.

In 1932 he resigned his chair, to follow Rosenhain as superintendent of the Department of Metallurgy at the National Physical Laboratory, remaining there until his retirement, in 1939.

Desch's next appointment must have surprised most of those who knew him, for in the November of that year he was appointed, by Securities Management Trust Ltd., to the board of Richard Thomas and Co., Ltd. In 1943 he resigned, on appointment as chief scientific adviser to the Whitehead Iron and Steel Co., Ltd. This complete change from academic to industrial life, however, seemed to give him real satisfaction. It was not his first experience of industry, and the possibility of applying his wide knowledge to the industrial needs of the country at a critical time was compatible with his life-long interest in sociological problems. These had, I believe, at an earlier date led him to become somewhat republican in his political thought, though this changed later, when he again became (mildly) royalist.

Desch's quite outstandingly successful book on metallography was followed, in 1914, by one on "Intermetallic Compounds". Despite all the changes which have taken place in the intervening years, this is still a book which may be read with profit, and was, when first published, of the greatest interest. In addition, and largely as a result of the visit paid, in 1931, to the United States of America, where he was the George Fisher Baker Lecturer at Cornell University, he published one of the earlier books on the solid state, the "Chemistry of Solids", largely based on the lectures which he gave there.

Over a number of years he was greatly interested in early metallurgy, as a result of which a number of reports were submitted to the British Association on the source of metals used by the Sumerians and other ancient peoples.

Elected to the Royal Society in 1923, he was president of the Faraday Society during 1926–28 and received the Bessemer Gold Medal from the Iron and Steel Institute and the Platinum Medal of the Institute of Metals, both the highest distinctions which these Institutes have it in their power to confer.

It was as a teacher, however, that Desch probably reached his highest level. He was an excellent lecturer, and the width of his knowledge enabled him to weave together facts and ideas obtained from an almost unique variety of sources. His mind was not strikingly original and his researches in metallurgy did not make any very lasting mark on its development.

This account of his scientific life and the important posts which he held gives, however, an inadequate description of the man himself. His complete sincerity of thought and his interest in human needs in general have already been mentioned. Among his relaxations was his interest in geology, a fact which led to his very good Sorby Lecture, delivered in 1921. His somewhat shambling gait was characteristic, but it carried him over many miles of rough country.

F. C. Thompson

Mr. H. E. Balch

Mr. H. E. Balch, honorary curator of the museum at Wells, Somerset, for sixty-one years, died on May 27 at the advanced age of eighty-eight.

Starting life as a messenger in the Post Office and finally rising to the position of head postmaster at Wells, he devoted the whole of his leisure time to the exploration of the Mendip Hills, and this in spite of the long hours of duty involved in his work. In 1893 he started a museum of his own material in the West Cloister of Wells Cathedral. An ardent collector himself, he soon persuaded others to give, and in 1928, through the generosity and interest of Mr. William Wyndham, the Museum was moved to a large house in the Cathedral Green. He was made chairman of the Trustees for life and honorary curator, a position he held until his retirement in 1954.

Balch had many publications to his credit, his major work undoubtedly being the large monograph on the excavations at Wookey Hole. He was awarded the honorary degree of master of arts in the University of Bristol in 1925 and was presented with the freedom of the City of Wells in 1944. He will be remembered with affection by many for his devotion and zeal to the elucidation of the problems of Mendip and for the amassing of such valuable collections which now and for the future will form the basis of the important museum at Wells. F. S. Wallis

NEWS and VIEWS

Ministry of Supply Electronics Research and Development (Telecommunications): Mr. R. G. Friend

Mr. R. G. Friend, who has been appointed director of electronics research and development (telecommunications) in the Ministry of Supply, read physics at Queens' College, Cambridge, where he was a Foundation Scholar and took first- and second-class honours in the two parts of the Natural Science Tripos. He then joined the Research Department, Woolwich Arsenal, where for some years he was engaged on research on X-ray and magnetic methods of material testing. In 1935, he transferred to the Air Defence Experimental Establishment for acoustical research with particular reference to the development of a new sound locator using electrical delay lines. Early in 1939, Mr. Friend was selected to move to Bawdsey to join a small team working with Sir Robert Watson-Watt on the application of the new radar techniques to Army problems. On the outbreak of war, this team moved to Christchurch, where it expanded and ultimately became the Radar Research and Development Establishment. Throughout the Second World War, Mr. Friend continued in this work and was responsible for many contributions in the fields of radar fire control for anti-aircraft guns and of counter-measures to radar jamming. He was for some years in charge of the Fire Control Group and later the Basic Techniques Research Group. In 1954 he moved to the headquarters of the Ministry of Supply on appointment as assistant director of electronics research and development. In this post, and later as acting director, he has been responsible for the research and development aspects of all ground radar for both the R.A.F. and Army applications.

Armament Research and Development Establishment : Dr. D. H. Black, C.M.G.

Dr. D. H. Black, who has been appointed director of the Armament Research and Development Establishment of the Ministry of Supply, in succession to Mr. E. McEwen, was born in 1899 in New Zealand, where he received his early education, taking first-class honours in physics at Canterbury. He came to Britain to work under the late Lord Rutherford in the Cavendish Laboratory, Cambridge, in 1923, gaining his Ph.D. in 1925. Dr. Black spent some fourteen years in industrial research with Standard Telephones and Cables, ultimately as head of the Valve Laboratory, before joining the Government service in September 1939, when he was appointed superintendent of the then Air Defence Experimental Establishment. In 1943, he was seconded to the Admiralty for special liaison duties in the United States, mainly concerned with new valve and electronic developments for radar and communications. He returned in 1945 as superintendent in charge of research at the now renamed Radar Research and Development Establishment, and in 1947 he moved to the headquarters of the Ministry of Supply, becoming director of electronics research and development in 1949. In 1953, Dr. Black was appointed head of the U.K. Ministry of Supply mission in Australia. During his three years in this post, the interests of the Ministry in Australia expanded considerably with the development of the guided weapon and atomic trials at Woomera and Maralinga. For his work in this post Dr. Black was appointed C.M.G. On returning to England in 1956, Dr. Black was appointed director-general of electronics research and development at the Ministry of Supply headquarters. Widely known in electronics and scientific circles, his appointment as head of the Armament Research and Development Establishment is indication of the increasing importance of electronics in all branches of armaments, as well as of his own personal and scientific strength.

British Scientific Instrument Research Association : Mr. R. J. Bracey

Mr. R. J. Bracey, head of the Optical Department of the British Scientific Instrument Research Association, will retire on July 31, after thirty-three years of service with the Association—and forty years of service to the optical industry. While still a boy, Bracey developed a deep interest in mathematics and a desire to apply his mathematical gifts to optical design, and after working for six years for a firm of shipbrokers and in a bank, he joined the firm of R. and J. Beck, the microscope makers. There he worked for the next seven years, in the shops and as a designer, until 1924, when Sir Herbert Jackson, then director of the British Scientific Instrument Research Association, invited Bracey to join the staff. Bracey's work during the next thirty-three years is reflected in the thirty-six research reports which bear his name or signature, twenty-four of them concerned specifically with optical design. Microscope objectives, including pioneering systems for ultra-violet microscopy; optical systems for telescopes; illuminators; focometers for spectacle lenses; systems of ray tracing; lens and mirror systems; interferometers; collimators; the optics of clinical thermometers; the examination of bearing jewels—Bracey's field has been wide. The $f/0{\cdot}36$ object-glass designed by Bracey for stellar spectroscopy at the Mount Wilson Observatory is one of his most important designs. Bracey's long service to the industry will not end with his retirement. It may be, indeed, that one of his greatest services is still to come, because the monograph on optical design which he is now writing and will complete in retirement may well prove to be an outstanding contribution to the literature of the subject. His services as a consultant will still be available to the Research Association.

Mount Wilson and Palomar Observatories : Dr. W. Baade

Dr. Walter Baade, who has been a member of the staff of the Mount Wilson and Palomar Observatories for twenty-seven years, is to retire. Dr. Baade, who was born at Schroettinghausen, in Germany, received his Ph.D. in 1919 at Göttingen and the same year was appointed to the staff of the Hamburg Observatory, where he remained until he received his appointment to the staff of Mount Wilson in 1931. Dr. Baade is noted for his discovery that two entirely different types of stars (Populations I and II) exist. This led to his recalibration of Cepheid variable stars in the Andromeda nebula, and his correction of the cosmic-distance scale. His work, which was reported at the International Astronomical Union meeting in September 1952, indicated that all objects beyond the Milky Way are about twice as distant as had previously been supposed. He has also collaborated with Dr. Rudolph Minkowski in the identification of celestial radio sources with visual objects, and in the physical interpretation of the nature of these sources. In 1954, Dr. Baade was awarded the Gold Medal of the Royal Astronomical Society, "for his observational work on galactic and extragalactic objects".

The Warren Spring Laboratory

The new Department of Scientific and Industrial Research Laboratory, now being built at Stevenage, will be called the Warren Spring Laboratory. The name is taken from a lane that used to run across the site on which the laboratory is being built. The Council for Scientific and Industrial Research has expressed the view that the Warren Spring Laboratory should be a versatile station, free to do work on any subject which becomes important for the nation and which cannot be fitted into the programme of another research body. It has already been decided that work will be carried out on air pollution; on the synthesis of oil and chemicals from carbon monoxide and hydrogen; and on mineral processing. The new station will, in addition, be free to take up any research requiring staff and facilities of the type that are being provided. Mr. S. H. Clarke, director of fire research, Department of Scientific and Industrial Research, has been appointed director of the Warren Spring Laboratory.

International Inspection of Nuclear Power Plants

A question was asked in the House of Commons on July 10 as to whether Britain would make it a condition of supplying civilian nuclear power plants to Brazil, Germany, Spain and other countries that continuous inspection should be undertaken by the International Atomic Energy Agency. The Prime Minister replied, pointing out that the Agency has not yet worked out methods for implementing the inspection and other safeguard provisions in its governing statute. All that can be done is to specify

in the contracts the right of supervision by the appropriate international agency. Contract orders placed this year, which will not operate before 1961 or 1962, will enable the Government to insist upon whatever methods of inspection seem proper and desirable. Mr. Macmillan also pointed out that the Agency is a board of twenty-three governors from as many countries with somewhat different approaches to this matter and that it may be difficult to get such a board to agree to adopt a particular form of technical operation. If it cannot be done in one particular way there may be some other agency or method for securing effective control; we have perhaps three or four years in which to work out the best method.

Nuclear Reactor for Winfrith Heath

In a written answer in the House of Commons on July 8, the Prime Minister said that it has been decided on technical grounds that the homogeneous aqueous reactor system planned for Winfrith Heath is not at present suitable for a major research and development effort, either by the Atomic Energy Authority alone or as a joint programme under the European Nuclear Energy Agency. Discussions are now in progress in the Agency about a joint research programme on the high-temperature gas-cooled reactor, a system which holds considerable promise for generating power but which has not yet been investigated in detail. This would include the construction of an experimental reactor in the United Kingdom, and Mr. Macmillan hoped that a satisfactory agreement will be concluded in the next few months. On the same day it was stated that the British Government contributes about one-quarter to the total budget for 1958 of £4,660,000 of the European Organization for Nuclear Research.

Research in the Aircraft Industry

The debate on the aircraft industry, which was opened by Viscount de L'Isle in the House of Lords on July 16, is of interest for the consistent emphasis laid on the importance of research by almost all speakers. Lord de L'Isle said that the industry is one of three or four in Britain in which it is vital to the national economy that it should gain and maintain a leading position in the world, and added that in this industry the demand to plough back money in research and development is the most insistent; he put the necessary figure at 20–30 per cent of turnover. Lord Ogmore, who asked again for an independent inquiry into the structure and situation of the industry, questioned whether it was possible to provide finance for research and development necessary for supersonic airliners from non-military sources alone, and said that about six of the 200 firms in the industry are responsible for 80–90 per cent of the output. The Earl of Swinton, urging that it is the duty of the Government to have a definite policy of development and to make this plain to the industry, argued firmly that we cannot afford to skimp expenditure on research, while Lord Adrian, pointing out that the aircraft industry is in the forefront of technological progress, said that there is scarcely any field of technical advance which did not receive an immense stimulus from war-time developments in aircraft. Instancing radio, metallurgy, engine design, electronic control and almost every kind of fine engineering, he said that the problem is whether we could afford to lose the technology which would go into the planes no longer required for defence, since it would be applied to machines and have just as much influence on industrial development as many developments in nuclear energy. The value of the applied research required for building a full-scale machine was not easily over-rated, and Lord Adrian believed that an important case can be made for Government sponsorship of the design and construction of some advanced machines. Viscount Caldecote strongly supported Lord Adrian's plea, pointing out also the vital need for continuity in research and suggesting allocation of finance for research and development over a five-year period: research cannot be stopped and restarted. He also supported Lord Weeks in a plea for clear guidance to the industry from the Government in policy. Lord Pakenham advocated the formation of a board in the Ministry of Supply, including industrial representation from outside the aircraft industry. Lord Mancroft, in reply, agreed as to the vital importance of research, but added little to the Minister of Supply's statement in the House of Commons on May 22 in reaffirming that the Government would continue to support the basic research necessary for the industry to survive, both in Government establishments and in industry, and that this would include the construction of research aircraft.

The Clean Air Act, 1956

As from June 1, 1958, the Clean Air Act, 1956, much of which has been in operation since the beginning of 1957, is fully in force, and it will be an offence punishable by fine to emit 'dark smoke' (defined as as dark or darker than shade 2 on the Ringelmann Chart) from any chimney in England and Wales. The ban on dark smoke applies to all buildings, and to railway engines and ships, but it will chiefly affect industrial and commercial premises, and the Minister of Housing and Local Government has issued a Memorandum on the Industrial Provisions (pp. 20. London: H.M. Stationery Office, 1958. 1*s*. net) to assist local authorities in administering these provisions of the Act. It directs attention to certain allowable defences and emphasizes the economies in fuel which can result from measures to reduce smoke. Surveys of Lancashire boilers carried out in 1956 by the National Industrial Fuel Efficiency Service indicate that adoption of measures to improve fuel efficiency on the 18,000 boilers in regular use should offer a saving of 3 million tons of coal a year against a capital expenditure of not more than £14 million. The Act also requires steps to be taken to reduce the emission of grit and dust from industrial chimneys. New furnaces installed after June 1 for burning pulverized fuel or more than 1 ton per hour of other solid fuel must be fitted with grit- and dust-arresting plant approved by the local authority.

European Agricultural Aviation Centre

A European Agricultural Aviation Centre has been set up under the auspices of the European Productivity Agency of the Organization for European Economic Co-operation, with headquarters at The Hague. Its task is to promote co-operation and efficiency in agricultural aviation in Europe and to act as a co-ordinating centre for the dissemination of information and the stimulation of research and development in this field. The need for such a centre has long been apparent in agricultural, industrial and scientific circles. The special type of aircraft used in

the application of crop-protection chemicals, fertilizers and seeds are expensive to construct and operate, and to pay their way must be employed to the full during the short season when they are required. This should be possible by operational pooling of the 200 aircraft available and by their use on a south-to-north basis following the seasonal advance. By promoting co-operation on a European scale, these aircraft can be used more efficiently and offer an invaluable adjunct to normal farming methods. During the first two years of its existence, the European Agricultural Aviation Centre will be supported financially partly by the European Productivity Agency and partly by the Dutch Ministry of Agriculture, Fisheries and Food; liaison officers in the participating countries (Denmark, France, Germany, Italy, the Netherlands, Sweden, the United Kingdom, Spain and Yugoslavia) will co-operate in its work. At the end of this period it is anticipated that the agricultural and industrial concerns which benefit from its work will contribute to the Centre's continuation and development, together with interested governments.

An Existing Cœlacanth, *Latimeria chalumnae*, in the British Museum (Natural History)

THE first specimen of an existing cœlacanth fish, *Latimeria chalumnae*, to reach Britain has been placed on view in the Fish Gallery of the British Museum (Natural History), London. It was brought over by Prof. Jacques Millot, director of the Institut Scientifique de Madagascar, together with a plaster cast of an earlier specimen, and presented to Sir Gavin de Beer, director of the Museum, to mark the occasion of the Fifteenth International Congress of Zoology. Cœlacanth fishes have a particularly long and interesting history. They are found as fossils in rocks laid down during the Devonian period, indicating that they were in existence some three hundred million years ago, and closely related fossils have been found in many parts of the world, including Europe, throughout the succeeding two hundred and thirty million years. None was known in any formation more recent than the Cretaceous, and cœlacanths were thought to have been extinct for the past seventy million years. In 1938, a large steel-blue fish with many extraordinary features, caught off the coast of East Africa, was identified by Prof. J. L. B. Smith, of Rhodes University, Grahamstown, as a living member of this ancient group. It was named *Latimeria chalumnae*, and since then about a dozen more specimens of *Latimeria* have been found.

Advertising

LORD Heyworth's address at the annual general meeting in London of Unilever, Ltd., on April 24, has been reproduced for private circulation under the title "Advertising" (pp. 17. London: Unilever, Ltd., 1958). In 1957, Unilever spent on advertising £83 million, nearly half in North America alone, and Lord Heyworth defends advertising as a prerequisite to real democratic freedom of choice and an aid to 'progress'; he also suggests that it promotes both the development of new products and their establishment on a more predictable basis. Particularly in the field of what economists term 'consumer durables', such as motor-cars, television sets and refrigerators, but also with soap powder and margarine, Lord Heyworth thinks that advertising brings savings to set against its cost. He refers briefly to the most recent means of advertising—television—and claims that in Britain it has provided an efficient means of communicating with consumers which has been welcome. Finally, Lord Heyworth emphasizes the need for market research, to enable the producer not only to give the customer what she wants but also to find out what she will want in the future.

National Parks in South Africa

THE Board of Trustees of the National Parks of the Union of South Africa has under its care five parks: the Kruger (7,340 sq. miles), Kalahari Gemsbok (8,050 sq. miles), Addo Elephant (26·5 sq. miles), Mountain Zebra (5·8 sq. miles) and Bonithole (2·8 sq. miles). Opportunities for research in these vast spaces are tremendous and much fruitful work has already been accomplished. To allow its investigations to become as widely known as possible, the Board of Trustees has launched a new journal devoted entirely to descriptions of work done in the National Parks (*Koedoe*, No. 1, 1958. (Journal for Scientific Research in the National Parks of the Union of South Africa.) Pp. 200. Published annually. Pretoria: National Parks Board of Trustees, 1958). Most of the articles are in English, while the few in Afrikaans have English summaries. Among the outstanding articles is a culicine mosquito survey of the Kruger National Park, some aspects of animal ecology in the Kalahari, and ancient and recent observations on hyænas. The journal has got off to a good start and deserves encouragement.

New Psychological Periodicals

Vita Humana (International Journal of Human Development. Vol. 1, No. 2, 1958. Pp. 65–128. Published quarterly. Basel and New York: S. Karger, 1958. 38.50 Swiss francs for 1 volume consisting of 4 numbers) is a new journal of human biology. It will be concerned principally with the psychological aspects of development, having particular regard to the maturation of behaviour in childhood and to changes in human performance with advancing age. The current part (1, No. 2) contains a report from Birmingham on the psychological status of deprived children and a discussion on the methodology of 'longitudinal research' in the study of human behaviour. The journal is edited by Prof. H. Thomae, of Erlangen, with an international advisory board.

Confinia Psychiatrica (Vol. 1, No. 2, 1958. Pp. 69–132. Published quarterly. Basel and New York: S. Karger, 1958. 38.50 Swiss francs for 1 volume consisting of 4 numbers) is devoted to the borderlands of psychiatry. It will be concerned less with clinical topics than with scientific and philosophical issues having relevance to psychological medicine. Summaries of papers are given in English, French and German. The editors are H. Heimann and Th. Spoerri.

Physical Review Letters

IT was announced in the April issues of the *Physical Review* that beginning with the issue dated July 1 the *Physical Review* will no longer carry the feature 'Letters to the Editor', but that the 'Letters' will be published separately in a supplementary fortnightly journal to be called *Physical Review Letters* (1, No. 1, July 1, 1958. Pp. ii+48). The new journal, which includes abstracts of future *Physical Review* articles, will initially be sent free of charge to all subscribers

of the *Physical Review*, though from January 1959 onwards a subscription will be charged (to members of the American Physical Society in the United States and Canada, 5 dollars; elsewhere, 6 dollars; to non-members in the United States and Canada, 10 dollars; elsewhere, 11 dollars. Subscriptions should be addressed to the American Institute of Physics, 335 East 45th Street, New York 17, New York). The object of the new journal is to obtain speedy publication and by the use of offset printing to reduce the time between receipt and publication of the letters to two to three weeks. On the average, about fifteen letters will be accepted for each issue and only if they contain important new discoveries or cover topics of high current interest in rapidly changing fields of research.

Government Museum, Madras

The Administration Report of the Government Museum, Madras, for 1955–56 (pp. vi+60. Madras: Government Printer, 1957), states that following an intensive campaign in publicity, including posters in railway stations all over India, the number of visitors shows a marked increase of 35 per cent over the previous year. Attention has been given to courses in museum technique, and these were held in the natural sciences, archæology, anthropology and chemical conservation. Much routine work has been accomplished in each Department and re-labelling has proceeded in English and Tamil. The Museum has also been very active in its Conservation and Photographic Departments. This work includes the treatment of ancient bronze images by electrolytic methods, and lead coins with dilute acetic acid under control.

Nutritional Requirements

A new Food and Agriculture Organization publication (Nutritional Studies, No. 16: Protein Requirements—Report of the F.A.O. Committee, Rome, Italy, October 24–31, 1955. Pp. v+52. Rome: Food and Agriculture Organization of the United Nations; London: H.M. Stationery Office, 1957. 3*s*. 9*d*. net; 0·75 dollars) deals with protein requirements in human nutrition. The report follows two others (No. 5, 1950; and No. 15, 1957), which considered calorie requirements. An attempt is made to assess the needs in terms of a reference high-quality protein (that from milk, eggs or meat). The report briefly discusses basic concepts such as nitrogen equilibrium, essential amino-acids and biological value. The estimated average minimum requirements, in terms of high-quality protein, range from 2·0 gm./kgm. body-weight in infants to 0·35 gm./kgm. for adults. To allow for individual variations in requirement, an increment of 50 per cent is recommended, with a further allowance because the dietary protein will usually be inferior to the reference protein. A section on the practical approach deals with ways of supplementing diets poor in protein and with ways of calculating allowances. An appendix outlines suggestions for further research.

Japanese Laminariaceæ

Algologists may be interested to know that the classic monograph "On the Laminariaceæ of Hokkaido" (1902), by the late Dr. K. Miyabe, is now available in an English translation (*J. Sapporo Agric. Coll.*, 1, pp. 50, with 29 plates; 1957). The monograph contains a general classification of the family and detailed descriptions of genera and species, with extensive notes on habitat and uses. The beautiful and interesting illustrations, which are a feature of the monograph, are well reproduced.

New Development of Philips Gas Refrigerating Machine

An addition to the range of the Philips gas refrigerating machine (see *Nature*, 180, 892; 1957) is announced by the distributors, Research and Control Instruments, Ltd. This new machine (the *PW* 7050) incorporates a nitrogen-separation column, by which means air can be liquefied and separated at atmospheric pressure to produce four litres of liquid nitrogen per hour. Continuous operation is possible for a period of one week before de-frosting becomes necessary. Special features of the *PW* 7050 are: fully automatic operation without the need of supervision; small dimensions compared with conventional equipment—the column stands approximately 6 ft. high; risk of contamination is negligible because the air is cooled at atmospheric pressure in a single stage and does not pass through any moving parts. Further information can be obtained from Research and Control Instruments, Ltd., Instrument House, 207 King's Cross Road, London, W.C.1.

Carlsberg-Wellcome Travelling Research Fellowships

The Carlsberg Foundation (Copenhagen) and the Wellcome Trust (London) announce a second series of awards of the Carlsberg-Wellcome Travelling Research Fellowships which they jointly instituted in 1957 (see *Nature*, 181, 743; 1958). The successful candidates for the academic year 1958–59 are Dr. S. E. Jensen and Dr. D. A. T. Dick. Dr. Jensen, of the Kommunehospitalet, Aarhus, and University of Aarhus, Denmark, will work in Prof. Russell Fraser's Department at the Postgraduate Medical School of London on the factors affecting serum lipoids in man, and Dr. Dick, from the Department of Human Anatomy, University of Oxford, will work with Prof. H. Holter at the Carlsberg Laboratory on the osmotic properties of living cells.

National Research Council of Canada: Scholarships

The National Research Council of Canada has granted 302 scholarships for the academic year 1958–59, with a total value of 414,700 dollars. These scholarships include ninety-four bursaries worth 1,000 dollars each and 145 studentships worth 1,200 dollars each, all of which are tenable in Canada. Special scholarships awarded for study abroad include forty-six awards worth 2,000 dollars each. These special scholarships are to be held in the following countries: twenty-one in the United Kingdom, twenty-two in the United States, and one each in France, Sweden and Switzerland. Seventeen postdoctorate overseas fellowships, valued at 3,500 dollars for married and 2,700 dollars for single fellows, have been granted for work in the following countries: eleven in the United Kingdom, and one each in Belgium, France, Germany, Italy, Sweden and Switzerland.

Granada Television Research Fellowship

Granada TV Network, Ltd., has offered a sum of not less than £30,000 to the University of Leeds to be spent over a period of five years in supporting

a Granada Television Research Fellowship and in providing the necessary ancillary staff. The offer includes further financial help and the possibility of renewal for a period if these should prove desirable. The purpose of the Fellowship will be to undertake research into the public impact of television over as wide an area of inquiry as practicable—social, æsthetic, political and commercial—and will cover television transmission from any sources in the British Isles. This study is one which will be of interest to a number of departments in the University, including social studies, economics, psychology, philosophy and history.

"Structure of Brain Ganglioside"

Dr. Samuel Bogoch, director of the Neurochemical Research Laboratory and senior psychiatrist, Massachusetts Mental Health Center (Harvard Medical School), has written in connexion with the note under this title published in *Nature*, February 1, p. 314. He states that "his communication under this title published earlier in *Nature* (July 27, 1957, p. 197) referred to previous related work by him (1953–55) from his Harvard doctoral thesis, and described recent work by him done at the Neurochemical Research Laboratory, Massachusetts Mental Health Center, in 1956 and 1957. The latter was supported by grants to Dr. S. Bogoch (principal investigator) from the National Institute of Mental Health and the National Institute of Neurological Diseases and Blindness (U.S.) (Grant No. *M*–1330: grant period June 1, 1956, to May 31, 1957; and Grant No. *B*-1221: grant period November 1, 1956, to October 31, 1957), and not by the American Cancer Society". The Editors of *Nature* have printed these statements from Dr. J. Folch-Pi and Dr. S. Bogoch, but they cannot give further space to the matter.

The Night Sky in August

New moon occurs on Aug. 15d. 03h. 33m. U.T., and full moon on Aug. 29d. 05h. 53m. The following conjunctions with the Moon take place: Aug. 7d. 10h., Mars 1° S.; Aug. 19d. 15h., Jupiter 0·9° N.; Aug. 23d. 08h., Saturn 3° S. In addition to these conjunctions with the Moon, Venus is in conjunction with Pollux on Aug. 10d. 23h., Venus being 6·7° S. Mercury is too close to the Sun for observation. Venus is a morning star, visible low in the south-east before sunrise. It rises at 2h. 10m., 2h. 40m. and 3h. 25m. on August 1, 15 and 31, respectively; its stellar magnitude is −3·3. During the month its distance from the Earth increases from 137 to 149 million miles and the visible portion of the apparent disk from 0·890 to 0·947. Mars rises at 22h. 45m., 22h. 05m. and 21h. 20m. at the beginning, middle and end of the month, respectively. Its stellar magnitude increases during the month from −0·1 to −0·5, its distance from the Earth decreasing from 86 to 70 million miles. Mars continues to move eastwards among the stars, being in Aries throughout the month. Jupiter sets at 22h. 10m., 21h. 20m. and 20h. 20m. on August 1, 15 and 31, respectively; it is near Spica. Conditions for the observation of Jupiter are becoming unfavourable; the planet may be visible low in the west after sunset. Its stellar magnitude is −1·4. Saturn sets at 0h. 35m., 23h. 40m. and 22h. 35m. at the beginning, middle and end of the month, respectively; it is near θ Ophiuchi. It has a stellar magnitude of +0·6 and a distance of 890 million miles from the Earth on August 15. There is one occultation of a star brighter than magnitude 6 visible at Greenwich: Aug. 5d. 00h. 40·5m., 147 B. Psc. (re-appearance). The Perseid meteors are active during the first fortnight of the month, maximum activity being on August 11. Conditions are favourable, the radiant being near R.A. 3h. 04m., Dec. +58°.

Announcements

Miss I. Phyllis Barclay-Smith, secretary of the International Committee for Bird Preservation, has been awarded the Silver Medal of the V. von Heidenstams Foundation in Sweden, for her work on behalf of the preservation of migratory birds. The Medal, which is rarely awarded to foreigners, was presented to Miss Barclay-Smith at Helsinki during the recent Conference there of the International Committee for Bird Preservation.

Mr. F. L. Barrett, of the Bleachers' Association Research Laboratories, Bromley Cross, has been made an honorary member of the Textile Institute.

The third International Neurochemical Symposium, on "The Chemical Pathology of the Nervous System", will be held at Strasbourg during August 25–29. Further information can be obtained from Dr. D. Richter, M.R.C. Neuropsychiatric Research Unit, Whitchurch Hospital, Cardiff.

A meeting on "The Biosynthesis of Phenolic Compounds in Plants", organized by the Plant Phenolics Group, will be held in Cambridge, on September 19, under the chairmanship of Sir Robert Robinson. Further information can be obtained from Dr. T. Swain, Low Temperature Research Station, Downing Street, Cambridge.

The thirteenth Symposium of the Society for Experimental Biology will be held at the University of Reading during September 15–19. The subject is "Utilization of Nitrogen and its Compounds by Plants". Further information can be obtained from the Hon. Symposium Secretary, Dr. J. F. Sutcliffe, 68 Half Moon Lane, London, S.E.24.

The British Society of Rheology is holding a meeting in the Department of Glass Technology of the University of Sheffield during April 15–17, 1959, on "The Rheology of the Glassy State". The meeting will discuss the mechanical and optical properties of inorganic and organic glasses and of high polymers in the glassy state. Intending contributors are invited to submit a title and detailed abstract (400–700 words) before September 15 to Dr. D. W. Saunders, British Rayon Research Association, Heald Green Laboratories, Wythenshawe, Manchester 22. Complete manuscripts will be required by mid-January 1959.

The third Congress of the Italian Society of Nuclear Biology and Medicine, arranged by the Medical Clinic of the University of Florence, will be held in Florence on November 3 and 4. All inquiries and applications for registration should be addressed to the Conference Bureau, Clinica Medica, Centro Radioisotopi, Viale Morgagni, Firenze, before September 15. Titles and short abstracts of papers (about 200 words) should be submitted before that date to the Segreteria della Società Italiana di Biologia e Medicina Nucleare, Clinica Medica, Pisa. The papers accepted will be published in a special issue of *Minerva Nucleare*.

BICENTENARY OF BOSCOVICH'S "THEORIA PHILOSOPHIÆ NATURALIS"

A MEETING was held on June 10 in the Yugoslav Embassy in London, at the invitation of the Ambassador, with Sir Harold Hartley in the chair, to celebrate the bicentenary of the publication in Vienna in 1758 of the "Theoria Philosophiæ Naturalis, redacta ad unicam legem virium in natura existentium" of Roger Joseph Boscovich, *S.J.* (born Ragusa, 1711; died Milan, 1787). The gathering represented many sciences and nationalities, reflecting the wide interests of a great eighteenth century figure.

Sir Harold Hartley opened with a brief sketch of Boscovich's relations with England and the Royal Society, of which he was made a Fellow on January 15, 1761, the same day as Sir Joshua Reynolds. Boscovich paid a visit to England in 1760, meeting many leading personalities, and incidentally served as Ambassador of the Free City of Ragusa, seeking to convince the British Government that Ragusa was not being used as a base by French warships. Sir Harold read a message from Prof. E. N. da C. Andrade describing the warm response of the Royal Society to Boscovich's visit, and of Priestley, Young, Faraday and Kelvin to Boscovich's ideas on the ultimate nature of matter, though the average student to-day may scarcely have heard of him.

Mr. L. L. Whyte then gave an address on Boscovich's theory of fundamental particles. Though Boscovich was recognized by his contemporaries as a distinguished mathematician, astronomer, geodesist, physicist, engineer and architect, as well as poet and diplomatist, his originality and influence were greatest in his "Theoria", where he developed in systematic form his doctrine of the constitution of matter. This was a kinematic theory of point particles[1], in which the traditional dualism (maintained by Newton and all Boscovich's scientific predecessors) of regions of space filled with matter contrasted with empty regions was discarded in favour of the simpler and more powerful 'Pythagorean' conception of spatial patterns of physical points, interacting in pairs in accordance with a single oscillatory law. Boscovich defined the general form of this law of central actions, but left the constants to be determined in the future. His theory was, in effect, a *programme for atomic physics* which a school of physicists has been carrying out since, until de Broglie introduced the wave-particle in 1923. Something might be gained by comparing the complex fields of 1958 with Boscovich's simple particles of 1758. Mr. Whyte showed that the great originality of Boscovich's conception had been recognized, not only by leading British and Continental scientists from 1760 to around 1920, but also by philosophers as varied as Nietzsche, Russell and Cassirer. It was of interest that both Nietzsche and Mendeléeff had put Boscovich with Copernicus as two of the most important and successful challengers of visual appearances.

A series of brief statements were then made on other aspects of Boscovich's work. Prof. Z. Kopal explained that Boscovich's contributions to astronomical science were in keeping with the trend of his times—the main achievements made during his lifetime were not in the field of discovery, but in the application of Newtonian gravitation to the theory of motion of celestial bodies, a work in which Boscovich took a prominent part. He shares honours with Laplace for the development of a method—still in use—for computation of cometary orbits based on three observations. As a professional astronomer for at least a part of his life-time, Boscovich perfected the stellar micrometer and, in 1770, became the founder and first director of the Brera (Milan) Observatory, which has remained in the forefront of Italian astronomical activities ever since.

Mr. C. A. Ronan discussed Boscovich's work in optics. He pointed out that in the eighteenth century corpuscular theories of light were the vogue but that Newton's theory of "easy fits of reflexion and refraction", which had been invoked to explain the partial reflexion and refraction occurring at the boundaries of surfaces of media having different refractive indices, was not fully appreciated. In Boscovich's theory of light the corpuscles were conceived of as rotating and having different polarities on their two sides, one being attracted by matter and the other repelled. Partial reflexion and transmission were thus explained. Moreover, this idea was invoked by others to explain, in conjunction with Boscovich's theory of matter, the penetration of light through solid bodies and the phenomena of astronomical refraction and of phosphorescence. Mr. Ronan also spoke of Boscovich's practical work in the design of an astronomical micrometer, his determination of the instrumental errors of the mural quadrant at Milan, his design of an equilibrium suspension for instruments of this kind, and his discussion of the residual errors inherent in such instruments and their reduction by appropriate design.

Dr. J. F. Scott considered Boscovich's contributions to pure mathematics, passing from his remarkable recognition of the possibility of a non-Euclidean geometry (for example, "these minds . . . would not seek, as our geometricians do, to rectify the parabola; they would endeavour, if one may use the words, to *parabolify* the straight line": "Theoria", § 116) to his advances in trigonometry, his brilliant essay on conic sections, his anticipation of the work of Legendre and Gauss on the calculus of observations, and his importance as one of the earliest foreign scholars to adopt the Newtonian theory of gravitation. Father L. J. Copplestone, *S.J.*, discussed Boscovich's atomism as an illustration of how a theory which is 'philosophical', as possessing wide implications, may provide the basis for a scientific theory which can be put to experimental test.

The Yugoslav Ambassador gave a lively sketch of Ragusa in Boscovich's time, and described how he established the first direct diplomatic relations between the Yugoslav peoples and Great Britain. Prof. I. Supek, president of the Boscovich Institute at Zagreb, brought greetings from the Yugoslav scientific societies and outlined the work of his Institute in research and teaching.

Sir Harold Hartley, in summarizing the contributions, stressed the part that Boscovich had played in establishing relations between the Southern Slavs and the United Kingdom, and the need for a biography of a great scientist recently unduly neglected. A scheme is under consideration for a volume combining a short biography with an extended report of the meeting covering additional aspects of Boscovich's scientific work.

[1] Recent studies of Boscovich's atomism, interpreting it as a kinematic theory, have been made by Whyte, L. L., *Nature*, **179**, 284 (1957), and *Notes and Records of the Royal Society*, **13**, 38 (1958); and by Jammer, M., "Concepts of Force", 170 (Harvard Univ. Press, 1957).

PHOTOCHEMICAL REACTIONS

THE Society of Physical Chemists of France organized a symposium on the transfer of light energy and photosensitization at the Physico-Chemical Laboratory of the University of Paris during May 27–30. In his introductory remarks, Prof. F. Perrin discussed the general principles of light-energy transfer and the life periods of activated molecules, fluorescence, chain reactions and their inhibition. D. Curie (Paris) presented the theoretical aspects of energy transfer and its mechanism in the crystals of luminescent minerals, such as zinc sulphide and potassium chloride. H. Haken (Erlangen) considered the theory of excitons and their role in the transfer of energy in the solid state. S. Nikitine (Strasbourg) described his experiments on the absorption, emission and reflexion spectra of thin layers of Cu_2O, HgI_2, PbI_2, CuBr, CuCl, TlI, TlBr, TlCl, CdS and CdI_2. Some experiments on the transfer of energy by excitons in cadmium sulphide were reported by E. Grillot (Paris), and N. Arpiarian (Paris) discussed the luminescence of zinc sulphide activated by gold and nickel at − 158° C.

A series of papers on the luminescence and energy transfer by organic compounds such as benzene, naphthalene, anthracene, chrysene, pyrene, dihydrodiphosphopyridine nucleotide, etc., were presented by workers from several countries. Other topics included the spectra of silver halides and the phenomena of optical sensitization and desensitization; photo-oxidations and photo-reductions and fluorescence of different organic compounds, colouring matters and their acceleration and inhibition; the transfer of light energy, fluorescence and mechanism of plant and algal photosynthesis. N. R. Dhar and co-workers (Allahabad) discussed their investigations on the increase of nitrogen fixation in soils on incorporating molasses, straw, grass, leaves, etc., by light absorption and calcium phosphates. The mechanism of this nitrogen fixation is based on the decomposition of water molecules into H and OH as in plant photosynthesis. As in animal metabolism and photosynthesis, phosphates are of great importance in nitrogen fixation. A. Szent-Györgyi (Massachusetts) contributed an important paper on the transfer of energy in muscles. This transfer is possible to distances greater than atomic dimensions.

As the world as a whole is short of food, intensive investigations on the acceleration of photosynthesis and soil nitrogen fixation are bound to be of great practical value.

On May 31 the Society celebrated its fiftieth anniversary at the Maison de Chimie, and addresses dealing with the progress of physical chemistry with special reference to France were delivered by Profs. R. Lucas, E. Bauer, R. Wurmser and A. Szent-Györgyi and the representative of the Minister of National Education in France.

THE GERMAN STARCH CONVENTION, 1958

THE International Starch Conference, held at Detmold during April 22–24, was well attended, with some 200 delegates from twenty countries.

In the section covering research and analysis, a paper was read by Dr. G. Gilbert (Birmingham), in which the action of air on aqueous solutions of starch was surveyed. An estimate has been made of the rate of hydrolysis of starch by pure water at 100° and 120° C., and it is found that the molecule of amylopectin is large enough to be affected by such hydrolysis during the dispersion of starch. The molecule of amylose, however, is too small to be affected by such hydrolysis, and it was suggested that oxidation by air contributes to the variation in the published values of the molecular weight of amylose. It was found possible to fractionate starch by dispersing it in cold sodium hydroxide under nitrogen and centrifuging the dispersion. Although sodium hydroxide is usually regarded as a good solvent for starch, the bulk of amylopectin was found to be quite insoluble in it under anaerobic conditions.

The development and present state of the starch industry in the United States was discussed by Dr. G. E. Hilbert (Washington). He reported recent success in growing a variety of maize, the starch from which contains 82 per cent amylose. It is hoped to raise this proportion to more than 90 per cent in the future. Amylose thus produced is cheaper than that obtained by chemical fractionation of starch. It is converted to the acetate, which is similar to cellulose acetate, and, moreover, it can also be digested in the stomach. Amylose acetate is therefore used for the production of such foodstuff adjuncts as sausage skins. Another development in the United States is the electrolytic oxidation of starch with periodic acid; the dialdehyde obtained is a good tanning agent for skins and is also used as a base for plastics.

Prof. M. Samec (Ljubljana) read a paper concerning the degradation of starch by γ-radiation. He reported in particular on the effects of the radiation derived from the betatron, X-rays and cobalt-60 on potato starch. Irradiation by cobalt-60 for 3 hr. was found to cause in starch complete loss of power to adsorb iodine. After 5 hr. the dialysable fraction had risen to 5·2 per cent and the reducing power had increased three-fold. After 7 hr. irradiation by

cobalt-60, a dispersion of starch in water was reduced to nearly the same viscosity as pure water. It was also found that the amylopectin fraction had acquired an acid *p*H.

It has been known in the confectionery trade that starch syrups, made by acid hydrolysis of starch, tend to become 'brittle' and cloudy when containing a high proportion of dextrose. Dr. G. Graefe (Hamburg) informed the meeting that stable syrups of low monosaccharide content can be produced by using initial starch dispersions of high concentration. The hydrolysis is carried out in two consecutive stages: first using acid to dextrose-equivalent 50, followed by treatment with malt enzyme.

The ion-exchange properties of freshly prepared and aged starch with heavy water have been studied by M. Čeh (Ljubljana). He reported that the rate of exchange of hydroxyl groups of amylose and amylopectin with heavy water (D_2O) has been measured by means of infra-red spectroscopy on dried films. It was found that the capacity to exchange ions of aged amylose films is much smaller than that of fresh films, whereas amylopectin similarly treated undergoes no change. Treatment of aged amylose films with potassium hydroxide or hot water restores the capacity to exchange with heavy water almost to its former value.

A. W. Davies (London) discussed the production of vital gluten and its application in Great Britain. Vital wheat gluten fulfils a useful function in the fortification of flour or bread doughs, on which it confers increased volume, improved crumb structure, keeping quality and flavour, while enhancing its nutritional value. It permits the manufacture of bread suitable for inclusion in diets prescribed in the treatment of certain clinical conditions. Gluten, at one time considered only a waste product, is rapidly becoming indispensable to the baking industry.

At the conclusion of the conference a meeting was held to discuss the project for standardizing the analysis of starch and its products on an international level. Work has already been started by ten committees covering such items as viscosity, ash, colour and protein content of starches. It was resolved to ask the International Organization for Standardization to take this project under its ægis and to organize further work in the many countries interested in it.

E. Dux

THE WOOL INDUSTRIES RESEARCH ASSOCIATION

REPORT FOR 1957–58

THE report of the Director of Research of the Wool Industries Research Association for 1957–58*, presented at the thirty-ninth annual general meeting on March 25, notes that the increase in the statutory levy obtained by the Wool Textile Research Council and the Wool Textile Delegation has enabled the Association to obtain a maximum grant from the Department of Scientific and Industrial Research. Work at Torridon on behalf of the Technical Advisory Committee of the Federation of British Carpet Manufacturers on the relative merits of East Indian, New Zealand and British wools for carpets has shown that East Indian wools may have a density as much as 30 per cent less than that of New Zealand wools because of the presence of medullated or hairy fibres. Wear tests of an experimental carpet indicate that the abrasive machines used by the Association correctly assess the results likely to be obtained in actual wear. The Association has accepted a sponsored project which aims at combining the Association's shrink-resistant process with some method of stabilizing the fibre, so that the shape as well as the size of the garment will be retained after washing.

Experience with the pilot scouring machine has emphasized the need for a more versatile set for research. The study of the effect of the nature and amount of residual grease from scouring, together with added oil, on breakage of fibres and subsequent tear on combing points to the possibility of considerable improvement. Trials at Torridon have substantiated the claims of some firms that special fancies can reduce the amount of fettling, but a very solid foundation of fettlings may be built up, removal of which is difficult without damaging the cloth. It is now reasonably certain that the region of high twist occurs in the short portion of yarn between the delivery rollers and spindle tip when the carriage is at its innermost position. This short length is twisted twice on successive draws and the double twisting is not completely removed before the yarn is wound on the top. Accordingly, reducing the length of yarn at the innermost position may be advantageous. Sintered metal bearings for mule spindles impregnated with polytetrafluoroethylene have performed very well under test and are being tried in the mill.

The Raper auto-leveller draw-box is being modified for use with the rotating can method to permit a greater output and larger packages from the draw-box. Considerable progress is reported in the analysis of spinning end-breaks, and extensive experiments have been made to determine whether the 'resting' of wool at different stages in processing contributes to any desirable qualities in the finished fabric. Scouring experiments have been completed with white worsted and fancy woollen pieces, and special scouring routines have been developed to overcome difficulties experienced with wool 'Terylene' worsted cloths, while light bars and streaks in these cloths have been traced to exposure to light before scouring, when the oxidation of the combing oil is accelerated, and this is more readily removed from 'Terylene' as its state of oxidation advances. A survey of crabbing routines in the mills of twenty-three firms was completed, and in the Scottish Laboratory a study of the effect of steaming and storage on wool oils emphasized the importance of tryptophan in the discoloration of wool. Experiments at the Rowett Research Institute on the effect of a light–dark rhythm on the growth of wool indicated a seasonal variation in production of

* Wool Industries Research Association. Report of the Director of Research for 1957–58. Pp. 30. (WIRA Publication No. 211.) (Torridon, Headingley, Leeds: Wool Industries Research Association, 1958.)

the wool, although the sheep were provided with a constant diet and maintained indoors. New methods have been applied to the fractionation of the soluble fractions and those precipitated iso-electrically from oxidized wool, and an apparatus was designed for following detergent action under the microscope, and another constructed for studying the visco-elastic properties of wool fibres over five decades below 1 cycle per second, under controlled conditions of temperature and humidity. Working at very high dilution to minimize association, infra-red spectroscopy has shown that both phenol and pyrrole react with the CO group of the secondary amide N-*n*-butylacetamide in carbon tetrachloride as solvent, and combination of neither compound with the amide modifies the infra-red absorption band of the amide NH group.

In his chairman's address at the annual general meeting, Mr. John Foster Beaver, reviewing changes in the circumstances and outlook of the Research Association, after a reference to its pioneering work on the control of relative humidity and on the fundamental properties and modes of operation of materials and processes used in the industry, said that the problem to-day was rather the significance for individual processing of the new knowledge being obtained from many other sources also. The Research Association had accordingly departed considerably from concentration on long-term research and was paying more attention to the immediate needs of the industry. During the past year more than 1,500 reports on consulting work were sent to members, and apart from solving an immediate difficulty, such reports indicate more general lines of research. For example, consulting work on stripey and barry pieces had led to an extensive programme on the effect of winding, warping and weaving tensions on the appearance of fabrics, which had indicated the degree of control required in these processes. During the year a series of six industrial lectures were given at Torridon on Saturday mornings as a new means of liaison with industry, and the attendance at these lectures had been extremely good.

THE PRODUCTION ENGINEERING RESEARCH ASSOCIATION

THE new building of the Production Engineering Research Association of Great Britain was formally opened by the Right Hon. Lord Chandos, at the Melton Mowbray, Leicestershire, headquarters of the Association on July 3.

These new premises—which have cost £250,000, of which £100,000 has been contributed by the Department of Scientific and Industrial Research—comprise extensive workshops and laboratories for the investigation and development of production engineering techniques. They house machine-tools, recording and testing instruments and auxiliary equipment worth some £500,000.

The acquisition of these facilities constitutes a major stage in the development of the Association, which had been working in temporary accommodation —converted stables—since it was founded in 1946. The Association was sponsored in its initial stages by the Institution of Production Engineers, the Gauge and Tool Makers' Association, the Machine Tool Trades Association, the National Federation of Engineers' Tool Manufacturers and the Department of Scientific and Industrial Research, and had its origin in the Institution of Production Engineers' Research Department which was established at Loughborough College in 1939 under the direction of Dr. G. Schlesinger, formerly of the Technical University of Berlin. Dr. Schlesinger was succeeded by his deputy, Dr. D. F. Galloway, who has been director of research at the Production Engineering Research Association since its foundation.

The Production Engineering Research Association is a non-profit making institution, deriving its income of about £250,000 a year partly from the subscriptions of 640 industrial companies and partly from the Department of Scientific and Industrial Research. It has a staff of about 250, and was established to assist member firms with their particular production engineering problems, undertaking practical investigations in the workshop or laboratory where necessary. Information services and technical training facilities are also provided. Visits are made regularly to each member firm by liaison engineers, members' staff are encouraged to visit the Association's workshops and laboratories, and there is a mobile unit equipped with cinema-cum-lecture theatre, and demonstration bay. A form of associate membership has recently been introduced for technical colleges and universities in Britain and the Commonwealth.

The primary objective of the Association is "to secure economic savings by the prompt and effective application of improved production techniques in members' workshops". One company has been shown how to save about £40,000 a year in the production of a single component; another is saving £30,000 a year by the cold extrusion of electrical components which had previously been produced by machining. Facilities are available for determining the causes of failure of components, for the selection and heat-treatment of materials, for testing lubricants, and for hardness and precision measurement.

But although mainly concerned with the solving of specific problems of member firms, much of the Association's work—particularly on metal-forming and metal-cutting techniques, for which it is very well equipped—is of general interest and application. From the point of view of those engaged in fundamental production engineering research in the universities, one can but regret that the private and confidential consulting nature of the Association's special investigations and development projects prevents the publication of findings which would undoubtedly be of considerable interest and value. Although it is recognized that the Production Engineering Research Association has an obligation to undertake investigations which bring immediate material benefits to the companies that finance its activities, it is to be hoped that as the Association further develops, and particularly in so far as it is a Government-sponsored research unit, the members of its team will be given freedom to initiate, pursue and publicize more work of a more fundamental character.

N. A. DUDLEY

ELECTRONIC COUNTING AND SIZING OF BACTERIA

By HERBERT E. KUBITSCHEK
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THE resistance method of counting and sizing particles in suspension[1] used for counting blood cells[2,3] has been extended to counting and sizing bacteria. This method measures the resistance of a conducting solution as a particle passes through an aperture. For this purpose, a Coulter counter (Coulter Electronics, Chicago) was modified in our laboratory. The original aperture, about 100μ in diameter, was replaced by a smaller one, some 10μ in diameter, through a glass sheet about 50μ thick. The circuitry of the counter was modified to prevent multiple recording of a given cell, and a pulse-height analyser was added to allow a more direct measurement of the distribution of cell volumes. Size distributions for a 4-hr. broth culture of *Escherichia coli*, strain *B*, and for *Bacillus megaterium* spores are shown in Fig. 1. Both suspensions were diluted in 0·1 *N* hydrochloric acid for counting and sizing. Other diluents which have been used are saline, buffers, and nutrient broth. This method of sizing should be applicable to any stable suspension of particles in an electrolyte, provided that the particle conductivity is either less, or only slightly greater, than the conductivity of the solution. It is particularly applicable to sizing biological cells, which have very high specific resistance to direct current.

The resistance method of counting and sizing has the following advantages over optical methods. First, the volume of each particle is measured, rather than some accidental value for an optical cross-section, the latter being a poor measure of particle size for particles of unknown shape. Secondly, in the presence of a background of small particles the signal-to-noise ratio is greater when volume is measured than when a cross-section is measured; the signal-to-noise ratio is further improved by the action of the aperture as a filter for large unwanted particles. Finally, the counter is simple to operate: samples are readily interchanged, and no optical apparatus is needed to view the particles.

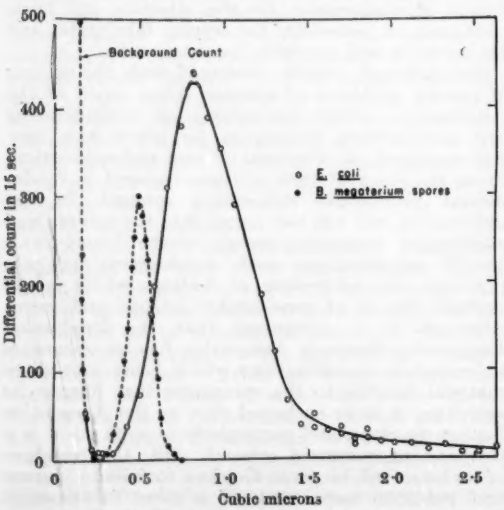

Fig. 1. Volume distribution of cell sizes of *E. coli* and *B. megaterium* spores

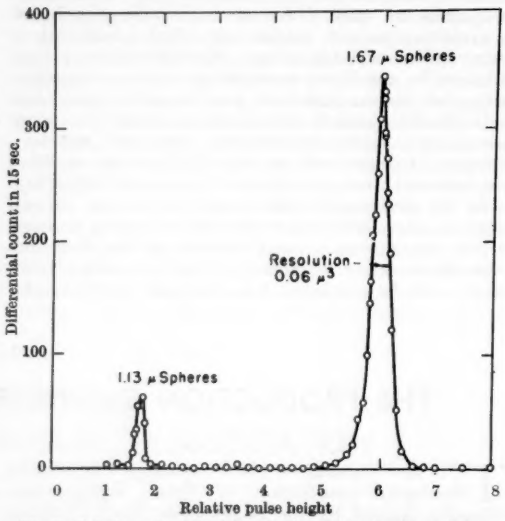

Fig. 2. Relative pulse-height distribution obtained with a mixture of 1·13μ and 1·67μ polystyrene spheres

To test the accuracy of counting, polystyrene latex spheres (kindly supplied by Dr. John Vanderhoff, Dow Chemical Co.), 1·13μ and 3·2μ in diameter, were suspended in saline and counted visually with the aid of a hæmocytometer to obtain absolute counts. The results were compared with values obtained with the counter. Corresponding determinations agreed within the standard error of 2 per cent of the mean. The counter is, therefore, an instrument for absolute counting of spheres at least as large as 30 per cent of the diameter of the aperture.

It can be shown that the change in the resistance of the aperture as a particle passes through it is proportional to the volume v of the particle, provided that the greatest cross-sectional area a of the particle is sufficiently small (and, of course, that the particle is shorter than the length of the aperture). For example, if the particles are right cylinders of resistivity ρ with axes aligned with the axis of the aperture, and if A and V refer to the cross-sectional area of the aperture and its volume, respectively, and ρ_0 and Ω the resistivity and the resistance in the absence of particles, then the fractional change in resistance of the aperture due to a single particle is:

$$\frac{\Delta\Omega}{\Omega} = -\frac{v}{V}\frac{\Delta\rho}{\rho}\left(1 - \frac{a}{A}\frac{\Delta\rho}{\rho}\right)^{-1}$$

where $\Delta\rho \equiv \rho - \rho_0$

When $\rho \gg \rho_0$ the change in resistance with respect to volume is linear to 1 per cent for right cylinders with diameters less than 10 per cent of the diameter of the aperture. This restriction upon particle diameter for linearity of sizing will be less severe when the resistivity of the particle is not widely different from that of the solution, and it also will be reduced for particles

with variable cross-section. (Particles with indentations are not considered here.)

To calibrate the counter for sizing, the relative diameters of 1·13-μ and 1·67-μ spheres were first determined by optical microscopy and by sedimentation in a sucrose gradient. The sucrose gradient measurements were kindly performed by Dr. John F. Thomson of this laboratory. Then the particles were sized electronically and gave, within 1 per cent, the same volume ratio.

The present resolution in volume determination varies between 0·04 and 0·06 cubic microns, corresponding to a linear resolution of about 2 per cent of the diameter for 1-μ spheres. This resolution is the observed half-width at half the height of the peak of the distribution, as in Fig. 2, observed with polystyrene spheres, which have a standard deviation in diameter of less than 1 per cent. The smallest particle volume which can be measured with the present aperture is about 0·2 cubic microns, as is evident from Fig. 1. This limit is set by the noise generated within the aperture, as well as the lesser noise in the electronic circuitry. The noise generated within the aperture is due to the electric current, to debris and, presumably, to localized heating within the turbulent stream.

This work was performed under the auspices of the U.S. Atomic Energy Commission.

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INFLUENCE OF WATER ON THE PHOTOLYTIC DECOMPOSITION OF OZONE

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EARLY work on the photolysis of dry ozone[1] established that the quantum yield was as high as 6·7 for light of wave-lengths between 2080 and 3130 A. Photolysis by visible light[2], however, always gave small quantum yields, the highest values being between two and three.

The fact that water vapour exerts a strong influence on the photolysis was clearly shown by Warburg and by Forbes and Heidt[3], who found that quantum yields varying from 1·6 to 130 could be obtained when ozone was mixed with water vapour and photolysed by light of wave-lengths 2800, 2540 and 2100 A. Forbes and Heidt were able to show that the quantum yield φ was roughly proportional to $\sqrt{[H_2O]}$. This and other experimental findings can be derived from a simple steady-state treatment of the system described later, involving the assumptions that the concentration of oxygen atoms at any time is small and that they are removed by reaction with water and not with ozone. The initiation reactions can then be represented by the three reactions:

$$O_3 + h\nu \rightarrow O_2 + O \quad (1)$$

$$O + O_3 + M \rightarrow O_2 + M \quad (2)$$

$$O + H_2O \rightarrow 2OH \quad (3)$$

which lead to the propagation reactions discussed below.

The results obtained from the early experiments on wet and dry ozone thus indicated that a chain mechanism is operative in both cases when ultra-violet light is used, and that the chain-length can be much greater when water vapour is present. In the case of the dry ozone, a simple atom chain-mechanism is inadequate to explain these results and it is necessary to invoke an energy chain, involving some form of excited oxygen. Absorption of light by ozone undoubtedly results in the production of one oxygen atom according to (1). For visible light this atom can only be in its ground-state ^3P. At wave-lengths less than 3100 A., however, dissociation can yield $O_2(^1\Delta g) + O(^1D)$. Subsequent reaction of either oxygen atom can then liberate a large amount of energy to produce some form of excited oxygen molecule according to the reaction:

$$O + O_3 \rightarrow O_2^* + O_2 \quad (4)$$

Early workers mostly assumed the excited state to be the electronic $^1\Sigma g^+$, but no direct evidence for this was available[4]. Using the technique of flash photolysis and kinetic spectroscopy, we were able to show that under isothermal conditions, that is, with an excess of inert gas, reaction (4) resulted in the production of vibrationally excited oxygen molecules, rotationally cold and in their electronic ground-states[5]. These molecules have sufficient energy to propagate a chain according to:

$$O_2^* + O_3 \rightarrow 2O_2 + O \quad (5)$$

Although ^3P oxygen atoms in reaction (4) are capable of releasing sufficient energy to account for the highest value of v'' observed (63·2 kcal./mole) the evidence was not conclusive in favouring $O(^3P)$ as responsible for the production of O_2^*.

Our recent work will now be outlined in brief. This, together with considerations of earlier work on the photolysis of wet and dry ozone by ultra-violet light, indicates beyond reasonable doubt that it is the $O(^1D)$ atom which is responsible for the chain-mechanism in both cases.

A very significant fact to emerge from the steady-state photolysis of dry ozone is that, when visible light is used, the value of the quantum yield φ is always small. Values have been obtained, however, between 2 and 3, under certain conditions, indicating that although $O(^3P)$ is not an efficient chain propagator it can initiate chains to a limited extent. This conclusion is supported by the work of Benson and Axworthy[6] on the pyrolysis of concentrated ozone mixtures with oxygen. They claim that the kinetics of the thermal decomposition can be explained without postulating an energy chain, and base their conclusion on the fact that, according to their interpretation, the O_2^* produced in reaction (4) with $O(^3P)$ must lose its excitation more rapidly than it can transfer it to ozone and bring about dissociation.

Using the technique of flash photolysis, outlined in a previous paper[5], we have now been able to show that absorption due to oxygen with v'' up to 17 can be detected immediately after dissociation of dry ozone

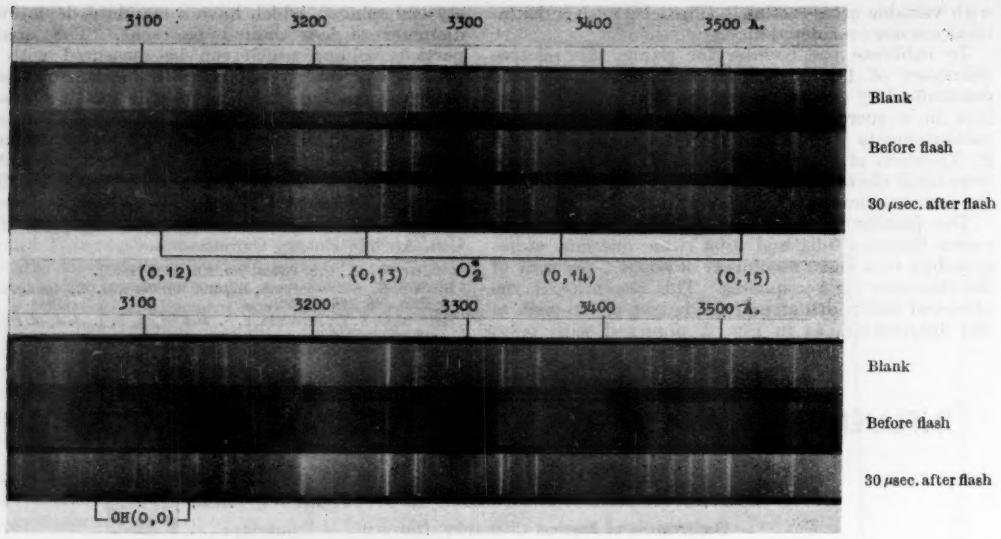

Fig. 1. Flash photolysis of ozone. *A*, dry ozone; mixture ratio ozone/nitrogen 1/100; ozone pressure 5 mm. mercury; *B*, wet ozone, mixture ratio ozone/water/nitrogen 1/3/100; ozone pressure 5 mm. mercury. Flash energy, 1,620 J.

by the flash. Repeated experiments with various mixture ratios and different partial pressures of ozone failed to detect any absorption with higher values of v''.

By introducing varying amounts of water vapour into the ozone/nitrogen mixtures we have been able to show that the effect of water on the photolysis can be attributed to the participation of OH radicals. With a mixture of ratio ozone/water/nitrogen (1/3/100) and a partial pressure of ozone of 5 mm. mercury, absorption due to OH can be detected at the shortest time attainable after flashing. The absorption is strongest at this time and decays relatively slowly. At the same time, production of vibrationally excited oxygen molecules is suppressed.

Production of OH radicals in these experiments must be brought about by reaction (3). For $O(^3P)$ this reaction is 16·8 kcal./mole endothermic, whereas for $O(^1D)$ it is 29·2 kcal./mole exothermic. It would seem certain, therefore, that under the conditions used in our experiments a considerable concentration of $O(^1D)$ atoms is produced, and that they must react preferentially with water to the exclusion of the reaction with ozone which forms the vibrationally excited oxygen in dry ozone. These facts are strikingly apparent in Fig. 1, in which corresponding mixtures of ozone and nitrogen are flashed under wet and dry conditions. Series *A* using dry ozone shows strong Schumann–Runge absorption; series *B*, with 15 mm. mercury of water vapour added, shows strong OH absorption and none due to O_2^*. In the figure only the (0,0) head of OH is shown. In agreement with this, Kistiakowsky[2] showed that decomposition in red light, which must involve ^3P oxygen atoms, is unaffected by water vapour.

These experiments indicate that the water molecules are very effective at mopping up $O(^1D)$ atoms and that it is this species which is responsible for the production of O_2^* during the photolysis of dry ozone. Subsequent reactions of the OH radical can now be written down to account for the high quantum yields previously observed as follows:

$$OH + O_3 \rightarrow HO_2 + O_2 + 42 \text{ kcal./mole} \quad (6)$$

$$HO_2 + O_3 \rightarrow OH + 2O_2 + 27 \text{ kcal./mole} \quad (7)$$

together with the possible chain-terminating reactions

$$2HO_2 \rightarrow H_2 + 2O_2 \text{ neutral} \quad (8)$$

$$2OH \rightarrow H_2 + O_2 + 12 \text{ kcal./mole} \quad (9)$$

$$2OH \rightarrow H_2O_2 + 46 \text{ kcal./mole} \quad (10)$$

$$2HO_2 \rightarrow H_2O_2 + O_2 + 31 \text{ kcal./mole} \quad (11)$$

This scheme, together with reactions (1), (2) and (3), leads to the following approximate formulæ for the quantum yield in wet ozone. In deriving the equation, k_6 and k_7 have been taken as equal and only one termination reaction is postulated.

$$\varphi = [O_3]\sqrt{\frac{K[H_2O]}{(k'[O_2]\,[M] + k''[H_2O]I_{abs.})}} \quad (12)$$

For the case when a large amount of oxygen is present, which was so in the work of Heidt and Forbes, this approximates to:

$$\varphi = [O_3]\sqrt{\frac{K[H_2O]}{K'[O_2]\,[M]\,I_{abs.}}} \quad (13)$$

If the light absorption is weak $I_{abs.} = kI_0[O_3]$ and

$$\varphi = \sqrt{\frac{K[O_3]\,[H_2O]}{K'[O_2]\,[M]I_0}} \quad (14)$$

These equations give the observed experimental facts such as the square root dependence of φ on the concentration of water.

Obviously from such a scheme high quantum yields are possible even when small amounts of water vapour are present, since the activation energies of (6) and (7) are not likely to be high.

The reason why $O(^3P)$ cannot propagate chains as readily at $O(^1D)$ in the photolysis of dry ozone is not entirely clear. Reaction (4) with $O(^3P)$ is 93 kcal./mole exothermic, and we have pointed out[7] that such a reaction could produce an oxygen molecule with a non-equilibrium value of vibrational energy well in excess of that required to dissociate ozone to ground-state molecules and atoms according to (15):

$$O_2^*(^3\Sigma g^-) + O_3(^1A) \rightarrow 2O_2(^3\Sigma g^-) + O(^3P) \quad (15)$$

The reaction requires 24 kcal./mole, which could be furnished by only 26 per cent of the total energy liberated in reaction (4). It may be concluded that $O(^3P)$ does not readily generate oxygen molecules with sufficient excitation for chain propagation.

For the production of $O(^1D)$ the primary step in the photolysis by ultra-violet light must be either:

$$O_3(^1A) \xrightarrow{h\nu} O_2(^1\Delta g) + O(^1D) - 91 \text{ kcal./mole} \quad (16)$$

$$\text{or } O_3(^1A) \xrightarrow{h\nu} O_2(^1\Sigma g^+) + O(^1D) - 106 \text{ kcal./mole} \quad (17)$$

Reaction (16) requires light of wave-length < 3100 A. and (17) wave-length < 2680 A. Subsequent reactions of the $O(^1D)$ according to (18):

$$O(^1D) + O_3(^1A) \rightarrow O_2^*(^3\Sigma g^-) + O_2(^3\Sigma g^-) \quad (18)$$

yield 138 kcal./mole, and it has been shown in our previous paper[7] that a high proportion of this energy appears as vibrational excitation of one of the oxygen molecules produced. Considerations of spin conservation rule out the production of excited singlet states in this reaction such as $O_2(^1\Delta g)$ or $O_2(^1\Sigma g^+)$.

Now in order for the chain to be propagated in dry ozone, the O_2^* produced in reaction (4) must in turn produce another $O(^1D)$ by reaction with ozone, according to:

$$O_2^*(^3\Sigma g^-) + O^3(^1A) \rightarrow 2O_2(^3\Sigma g^-) + O(^1D) \quad (19)$$

This requires 70 kcal./mole and hence only those O_2^* molecules with vibrational energy in excess of this will be effective. It is very significant that the highest value of v'' observed in the flash photolysis of ozone is 17, which corresponds to an energy of 66·7 kcal./mole—just too small to bring about reaction (19)—but the following value of v'', that is, 18, corresponding to 70 kcal./mole, is missing. It can be reasonably concluded that all such molecules with 18 or more quanta react by (19) so rapidly that no appreciable concentration builds up to enable their detection by spectroscopic means.

The argument outlined here explains adequately all the features of the photolysis of both wet and dry ozone with light of various wave-lengths. It seems certain that the chain mechanism in both cases is ultimately due to the presence of the $O(^1D)$ atom, which, because of its high energy and ability to react according to (4) without any activation energy, can either produce O_2^* molecules with sufficient energy to propagate a chain reaction, or when water vapour is present to react according to (3) and yield OH radicals from which a radical-propagated chain is derived.

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ENDOGENOUS METABOLISM IN BRAIN CORTEX SLICES

By Dr. R. VRBA and JAROSLAVA FOLBERGR

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IT is known that brain cortex slices take up a considerable amount of oxygen when incubated without added substrate[1,2]. The consumption of lactic acid and carbohydrate contained in brain slices accounts for only a fraction of the observed total uptake of oxygen[2]. It is well known that ammonia formation is considerably increased when nervous tissue, and especially brain cortex slices, are incubated *in vitro* without added substrate[1-9]. It seems probable, therefore, that the endogenous metabolism of brain slices is connected with ammonia formation[2].

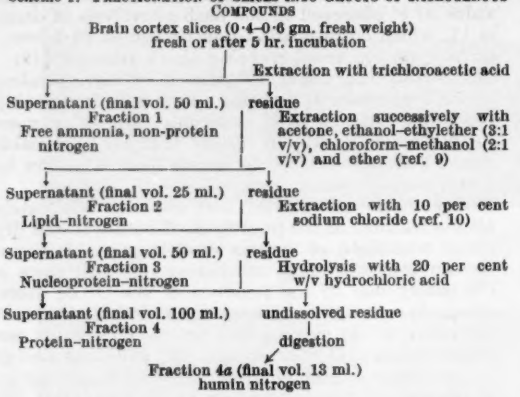
We have observed that ammonia formation in brain slices is accompanied not only by an increase of non-protein nitrogen, but also by a marked increase of lipid-nitrogen, that is, nitrogen-containing substances are transferred from the protein fraction to the lipid fraction[6,9]. It is suggested that all three processes, namely, the increase of ammonia, of non-protein nitrogen and of lipid nitrogen, may have a common root. The present experiments were an attempt to find this common source of nitrogen in brain slices, by using a simple fractionation of nitrogenous compounds in fresh and incubated slices to account quantitatively for all transfers of nitrogen.

In these experiments, only large batches of slices were used for analysis (400–600 mgm. wet weight). This diminishes the effect of individual variation between slices. All results are expressed as percentages of the total nitrogen of the slices instead of the wet weight, because despite the usual precautions it is difficult to remove the adhering liquid in a way that can be reproduced.

Each experiment was performed with twelve Warburg vessels, each containing 4 ml. of Krebs–Ringer phosphate saline without added substrate. To six vessels (non-incubated controls) 1 ml. of 50 per cent w/v trichloroacetic acid was added before the slices were introduced. Freshly cut guinea pig brain cortex slices (60–100 mgm. wet weight) were introduced into all vessels, and the six vessels not containing trichloroacetic acid were incubated in a Warburg apparatus for 5 hr. in oxygen, with shaking, at 37° C. After the incubation the vessels were detached from the manometers, and after the addition of 1 ml. of 50 per cent w/v trichloroacetic acid to each incubated vessel, the contents of these were combined. The contents of the unincubated vessels were similarly treated. Thus, two large samples of fresh and of incubated slices were obtained. Trichloroacetic acid extracts were prepared as described in more detail elsewhere[9]. The final volume of the extract was 50 ml. The rest of the tissue was then fractionated into various main groups of nitrogenous compounds according to scheme 1.

Aliquots of all four fractions were digested; free ammonia was estimated[1] in fraction 1. The digests were distilled in a Markham apparatus[10] and ammonia estimated by nesslerization.

Scheme 1. Fractionation of Slices into Groups of Nitrogenous Compounds



Results of five experiments are recorded in Table 1. It may be seen that during incubation an increase of ammonia nitrogen, of non-protein nitrogen and of lipid nitrogen occurs; this increase is quantitatively accounted for by the decrease of the nitrogen in the protein and nucleoprotein fraction.

The density of the sodium chloride extract was measured in the ultra-violet, using the Soviet spectrophotometer *SF*-4, and absorption curves constructed. The measured densities were referred to 10 mgm. of total nitrogen in slices (Fig. 1). It may be seen that extracts of incubated slices show lower absorption, confirming the results in Table 1, namely, that during incubation of slices a degradation of the nucleic acids occurs. Evaluation of the results of four experiments performed are recorded in Table 2.

The fact that nucleic acids are metabolized during incubation of brain cortex slices raises the problem of the fate of the pentose in these compounds. The

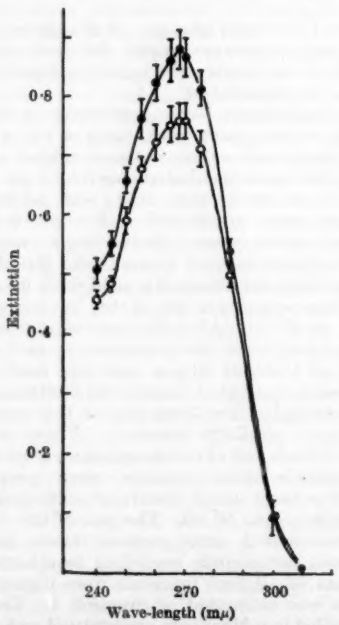


Fig. 1. Ultra-violet absorption curve of the sodium chloride extract of four experiments: ●—●, before; ○—○, after 5 hr. incubation at 37° C. with oxygen

Table 1. Nitrogen Changes in Guinea Pig Brain Cortex Slices after 5-hr. Incubation in Krebs–Ringer Phosphate Saline without Added Substrate

Fraction	Initial	Final	Average difference	Balance
Free ammonia (ref. 1)	0·55 ± 0·08	2·73 ± 0·13	+ 2·18	+ 8·64
Non-protein nitrogen (not including free ammonia)	7·14 ± 0·54	11·14 ± 0·24	+ 4·00	
Lipid nitrogen	5·27 ± 0·57	7·73 ± 0·45	+ 2·46	
Nucleoprotein nitrogen	21·77 ± 1·49	17·65 ± 0·31	− 4·12	− 8·63
Protein nitrogen	61·87 ± 1·59	57·92 ± 0·62	− 3·95	
Humin nitrogen	3·39 ± 0·09	2·83 ± 0·17	− 0·56	

Results are expressed as percentages of total nitrogen. The means and standard errors of five experiments are given. All differences are significant ($P < 0·01$)

Mejbaums orcinol reagent was added to aliquots of the sodium chloride extract and pentoses were estimated colorimetrically[11]. As bound pentoses give a different density from free pentoses with this method, no standards were used, but the densities of extracts of fresh slices, after correction to the standard weight of 10 mgm. of total nitrogen in slices, were compared with similarly recalculated densities of the sodium chloride extracts of the incubated slices. A significant decrease of pentoses in this fraction occurs (Table 2). The deficit of pentoses in the nucleoprotein fraction cannot be accounted for by an increase of pentose in the fraction soluble in trichloroacetic acid, for an even more marked decrease of pentoses was found in this fraction by the same procedure (Table 2).

Table 2. Pentoses and Nucleic Acids after 5 hr. Incubation of Brain Cortex Slices in Krebs–Ringer Phosphate Saline without Added Substrate

1 Pentoses in Fraction 1 (trichloroacetic acid extract)	2 Pentoses in Fraction 3 (sodium chloride extract)	3 Nucleic acids in Fraction 3 (optical density of the extract at 268 mμ)
62·3 ± 2·7	82·8 ± 6·9	86·9 ± 5·7

Results are expressed as percentages of initial values. The means and standard errors of four experiments are given

Only small, constant amounts of orcinol-positive substances were found in acid hydrolysates of evaporated aliquots of the lipid fraction, as in the protein fraction. The conclusion to be drawn from these experiments is that degradation processes in the protein and nucleoprotein fraction, occurring during incubation of brain cortex slices, account for the accumulation of ammonia, of non-protein nitrogen and of lipid nitrogen, and are accompanied by utilization of endogenous bound pentose.

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OBSERVABILITY OF SPONTANEOUS TEMPERATURE FLUCTUATIONS

By T. P. GILL

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A NUMBER of authors, for example, Milatz and van der Velden[1], Daunt[2] and Chasmar *et al.*[3], have discussed the fundamental limits to the sensitivity of bolometers and other thermal radiation detectors. The two natural limits are Johnson noise and spontaneous temperature fluctuations in the case of the bolometer element. The following brief discussion illustrates the way in which these fluctuations may be treated.

The most important symbols used are:

$\overline{\Delta V_\theta^2}$, mean square thermal noise voltage;
$\overline{\Delta V_J^2}$, mean square Johnson noise voltage;
k, the Boltzmann constant (watt deg.$^{-1}$);
T, absolute temperature of bolometer strip (deg. K.);
T_0, absolute temperature of environment (deg. K.);
r, electrical resistance of bolometer strip (ohm);
Δf, narrow frequency band-width in which observations of noise are made;
i, measuring current in bolometer (amp.);
β, temperature coefficient of resistance of bolometer strip, defined in this case as $(1/r)(dr/dT)$;
R, real part of thermal impedance of bolometer strip to surroundings at frequency f cycles/sec.;
A, total area of bolometer (cm.^{2});
σ, Stefan–Boltzmann constant (watt cm.$^{-2}$ deg.$^{-4}$);
η, bolometer emissivity.

The fluctuating voltage across the bolometer terminals, which ultimately defines the minimum detectable power, is usually derived from the following relations:

$$\overline{\Delta V_J^2} = 4kTr\Delta f \qquad (1)$$

$$\overline{\Delta V_\theta^2} = i^2r^2\beta^2 \cdot 4kT^2R\Delta f \qquad (2)$$

for Johnson noise and temperature fluctuations, respectively.

The total mean square noise voltage is thus found to be:

$$\overline{\Delta V^2_{\text{Tot.}}} = 4kTr\Delta f\,(1 + i^2r\beta^2TR)$$

In discussing the minimum detectable power of bolometers the next step is to introduce a formula for the sensitivity in volts per watt. However, it is proposed here to consider only the noise voltage appearing at the bolometer terminals. For sufficiently low frequencies, R can be taken as $(4\eta A\sigma T^3)^{-1}$ when the bolometer is operated *in vacuo*, and i^2r may be written as $\eta A\sigma(T^4 - T_0^4)$.

Thus,

$$\overline{\Delta V^2_{\text{Tot.}}} = \overline{\Delta V_J^2}\{1 + \tfrac{1}{4}(1 - T_0^4/T^4)\beta^2T^2\} \qquad (3)$$

For a metal bolometer, βT is in the neighbourhood of unity, and since T_0 must be less than T we have:

$$\overline{\Delta V_J^2} < \overline{\Delta V^2_{\text{Tot.}}} < 5/4\ \overline{\Delta V_J^2}$$

Unless β can be increased by about an order, $\overline{\Delta V_\theta^2}$ will usually be small compared with $\overline{\Delta V_J^2}$. Unfortunately, materials which have a large β usually show current noise which masks $\overline{\Delta V_J^2}$ as well as $\overline{\Delta V_\theta^2}$. The matter is made worse by the fact that the frequency spectrum of the current noise resembles that of $\overline{\Delta V_\theta^2}$ and both vary in a similar way with i. Valve noise in amplifiers also increases at low frequencies in a somewhat similar manner.

We may, however, question whether this procedure of adding $\overline{\Delta V_\theta^2}$ and $\overline{\Delta V_J^2}$ is in fact valid, since both types of fluctuation are manifestations of the same underlying phenomenon. If we cannot add these fluctuations, then the bolometer will be limited ultimately by Johnson noise, which implies that the presence and magnitude of spontaneous temperature fluctuations in bolometers should really be unobservable.

In general, it is quite wrong to expect to be able to derive fluctuations in various properties of a body from temperature fluctuations occurring spontaneously, using the normal temperature coefficient. For example, in a gas the random variations in pressure, density and temperature are not connected by the ordinary macroscopic gas laws—each of them is a different aspect of the statistical fluctuations in molecular position, velocity, etc., and they are not causally related in the sense that one can be regarded as giving rise to another. The concept of temperature itself requires careful examination in the microscopic case, since we find that heat flow is no longer simply related to temperature gradient. There are certain types of temperature-measuring devices, namely, those in which no power is supplied from outside, for which it can be shown that these spontaneous temperature fluctuations are inherently unobservable. This may be illustrated by two examples.

In the first, let us consider a very sensitive and delicate bimetallic strip which is used as a thermometer, the movement of its one free end being taken to indicate the temperature. It will undergo spontaneous fluctuations in temperature given by the well-known relation $\overline{\Delta T^2} = kT^2/c$, where $\overline{\Delta T^2}$ is the mean square temperature change and c is the thermal capacity of the body. If a temperature change of 1° C. produces a displacement S of the strip we might expect to observe a resulting fluctuation $\overline{\Delta x^2} = S^2kT^2/c$.

However, the strip must also execute Brownian motion, which is given by the relation $kT/2 = g\overline{\Delta x^2}/2$ (g being the stiffness of the strip) leading to $\overline{\Delta x^2} = kT/g$. It is clearly inadmissible to add these two fluctuations, since if we did so we would have a body with a mean kinetic energy (for this particular degree of freedom) in excess of the equipartition value.

For the second example we may consider a galvanometer, to the terminals of which a sensitive thermocouple is connected. Because of the equipartition law, the mean kinetic energy of the galvanometer suspension will be unaffected by any temperature fluctuations which may occur in the thermocouple, or for that matter by the presence or absence of the thermocouple, nor would the fluctuations exhibited by means of a valve amplifier exceed the normal Johnson noise (plus, of course, valve noise), provided always that the whole system is at

the same temperature. This point is discussed in some detail by McCombie[4] and Jones and McCombie[5].

In considering the case of a galvanometer, Astbury[6] adds the fluctuations due to Johnson noise to the normal Brownian movement of the suspension. Even without the more sophisticated approach of Jones and McCombie it seems wrong to do this because of the resulting deviation from equipartition which could, in principle at least, lead to the establishing of a temperature gradient in a spontaneous manner. A somewhat similar operation to Astbury's is implied in a paper by Strong[7] and one dealing with thermopiles by Hornig and O'Keefe[8].

Referring to the bolometer, McCombie[4] says that, "unlike the thermocouple, [it] is not an equilibrium system. The strip, of which the change in temperature is to be measured, carries a steady current in order to convert changes in resistance into changes in voltage. There is, therefore, no reason to expect that the fluctuations can be discussed in terms of Nyquist's result". From this it is clear that to use arguments based on equilibrium conditions is unsound. Now the Nyquist–Johnson formula, equation (1), is, of course, based on equilibrium conditions but still is found to hold for metallic conductors even when they are carrying current. Equation (2) also may be derived from a consideration of equilibrium conditions (see ref. 2). It is, in fact, quite common to treat the bolometer as an equilibrium system, although this cannot be justified except by the correctness of the results obtained. In other words, if we are justified in treating the bolometer as an equilibrium system, it is not clear that we should expect to be able to observe spontaneous temperature fluctuations. If we are not so justified, our conclusions will be open to question in any event. It therefore seems desirable that the question should be examined experimentally.

I have carried out[9] a number of experiments with evaporated-gold bolometers as small as 0·2 mm. square, but in no case has a condition been achieved where the spontaneous fluctuations in temperature might be observed. The reason for this was mainly the fact that the gold in the thin film used had a temperature coefficient of resistance of the order of one-third of that of the bulk metal, which reduced βT to about 1/3 and would therefore have required the root-mean-square noise to be measured to much better than 5 per cent, which was beyond the capabilities of the equipment used. Current noise was also present in most cases, and even where it was small compared with Johnson noise could still mask any temperature fluctuations. Other considerations have prevented the subject being pursued, but it seems possible that the problem might be attacked using thin platinum strips, similar to those used by Chasmar and others[3].

It will be noticed that the thermal capacity of the bolometer does not enter into equation (3); but this does not mean that we can therefore use robust resistance thermometers. The apparent paradox is produced by our limiting ourselves to 'sufficiently' low frequencies, and a more complete analysis shows that in practice a very delicate device indeed must be used if we can realize the figure given by equation (3).

The arguments above are by their nature not rigorous, but nevertheless it is felt that a case has been established for reviewing the assumption that spontaneous temperature fluctuations are observable, as such, particularly in the case of the bolometer.

I wish to acknowledge my indebtedness to Dr. F. W. Woltersdorf, formerly of the Department of Supply, Commonwealth of Australia, for many fruitful discussions on the subject of this communication and allied topics, and to thank the Chief Scientist, Department of Supply, for permission to publish it.

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LIVER GLUCOSYL OLIGOSACCHARIDES AND GLYCOGEN: EFFECTS OF STARVATION, GLUCOSE FEEDING AND INSULIN

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RECENTLY, we have succeeded in isolating and identifying rat liver maltose, maltotriose and maltotetraose, and in recognizing higher members of an ascending homologous series of glucosyl oligosaccharides[1]. These were findings made unexpectedly during an investigation of the nature of glucosiduronic acids in liver.

The purpose of the present article is to present other results which justify the giving of more than passing attention to the question of the significance of these hepatic glucosyl oligosaccharides.

Male albino rats (250 gm.) were fasted for different lengths of time up to 24 hr. and then killed. The liver was removed and two 1-gm. portions of it were frozen (deep freeze) and analysed later for glycogen by Roe's method[2] and for glucosyl oligosaccharides by the method described in the following paragraph.

A 1-gm. specimen of liver was homogenized in 10 ml. of cold distilled water and was immediately deproteinized with 1 ml. 10 per cent zinc sulphate solution and 1 ml. 0·5 *N* sodium hydroxide solution. After centrifugation, the supernatant was collected, and washings of the precipitate (3 portions of 10 ml. cold water) were added to it. Supernatant and washings were pooled and treated with 3·0 gm. activated charcoal for 5 min. at room temperature. The charcoal was collected on a Buchner funnel and washed repeatedly with 20-ml. portions of water (total volume 250–500 ml.). The oligosaccharides were eluted from the charcoal with 3 × 20 ml.

portions of hot ethyl alcohol (95 per cent). Then the charcoal was transferred to a beaker and extracted with 2 × 20 ml. of hot ethanol, which was decanted and filtered finally through the original Buchner. An aliquot (0·2–1·0 ml.) of the alcoholic eluate was analysed by the Dische reaction[3]. The recovery of pure maltose when treated as above was 97 per cent and as little as 2–5γ of it can be measured. The results are expressed as mgm. of oligosaccharides per 100 gm. of liver in terms of the number of glucosyl residues. The results are shown in Fig. 1.

After 24-hr. starvation, glucose (2·0 gm. in 3·5 ml.) was administered by stomach tube. Of these animals, 6 received a second dose of 2·0 gm. of glucose 28 hr. after time zero. At the time-intervals indicated in Fig. 1, the animals were killed and their liver oligosaccharides and glycogen determined as described above.

It was observed that on starvation, rat-liver glycogen underwent a progressive and regular decline to disappearance-levels after 8 hr. In the case of the glucosyl oligosaccharides, a parallel decrease was observed but not to the same extreme degree as was noted for glycogen. In this regard, it may be reasoned that if the oligosaccharides were derived solely from glycogen breakdown, then coincident with the profound drop in liver glycogen one should expect to find a noticeable increment in liver oligosaccharides. This event did not occur.

The administration of glucose to starved rats caused a rapid restoration of liver glycogen to the pre-starved level, as expected. The amount of liver oligosaccharides increased also but at a slower rate than was the case for glycogen.

Liver glycogen and glucosyl oligosaccharides were determined 2 hr. after 6 rats received 4 units each of insulin (Lilly) subcutaneously (Fig. 2).

Insulin administration resulted in a characteristic marked decrease in hepatic glycogen[4]. This was accompanied by a parallel diminution in glucosyl oligosaccharides (Fig. 2). Qualitatively, similar

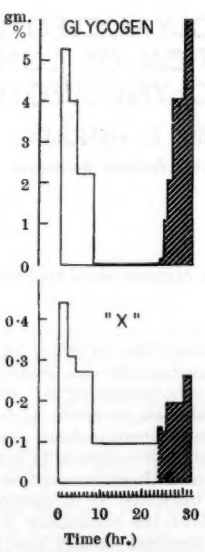

Fig. 1. Liver glycogen and glucosyl oligosaccharides ("*X*") in relation to hours of starvation and to subsequent glucose administration (shaded areas). The numbers of rats employed for each time-interval (hr.) were, respectively: 0–2, 11; 2–4, 4; 4–8, 5; 16–24, 10; 24–25, 6; 26–27, 6; 27–30, 6; 30–32, 8

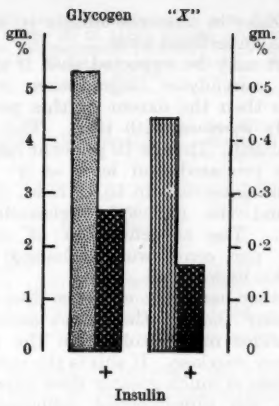

Fig. 2. Effect on liver glycogen and glucosyl oligosaccharides of subcutaneously injected insulin. Six rats maintained on an *ad libitum* diet were killed as controls for six other rats which were killed 2 hr. after receiving the insulin

results were obtained in rats starved for 24 hr. and then given glucose and insulin.

Thus, in three different sets of physiological circumstances (starvation, glucose feeding, insulin administration), hepatic glucosyl oligosaccharides fluctuated in the same direction as did liver glycogen.

The possibility of artefacts due to the isolation is unlikely inasmuch as the glucosyl oligosaccharides can be separated from liver by simple physical means (centrifugation, dialysis) and since no oligosaccharides result from glycogen which has been subjected to the isolation process[1].

The possibility was also considered that oligosaccharides were produced from glycogen by amylase in blood contaminating the liver homogenate. The duration of this action would be the interval separating removal of the liver to the deproteinization of the homogenate.

In this connexion, it was first shown that rat-liver supernatant does not produce detectable amounts of oligosaccharides from glycogen or starch in the time interval referred to above. Thus, 2 gm. of fresh rat liver were homogenized in 15 ml. of ice-cold distilled water and centrifuged at high speed in a refrigerated centrifuge for 30 min. The supernatant was tested for amylase activity using two substrates, starch and glycogen. The soluble starch (1 per cent) was made up in phosphate buffer *p*H 6·9 according to Bernfeld[5] and the glycogen (1 per cent) in 0·02 *M tris* buffer (*p*H 7·4) and 0·0067 *M* sodium chloride. The experimental digests contained 1 ml. of buffered substrate and 1 ml. of liver supernatant solution. The controls contained boiled supernatant. The digests were incubated at 20° C. for 3 min. and the reaction stopped by boiling. The addition of 0·5 ml. of 10 per cent zinc sulphate and 0·5 ml. 0·5 *N* sodium hydroxide precipitated the protein, which was filtered off. The reducing power of the filtrate was determined[6]. No increase in reducing power of the test digests versus controls was observed, signifying the absence of amylase activity under the conditions employed.

Moreover, experiments were done in which the portal vein of the liver of a nembutalized rat was perfused *in situ* with Ringer's solution to remove as much as possible of the blood trapped in the tissue. Subsequent analysis showed the presence of glucosyl

oligosaccharides in amounts similar to those usually found in the unperfused liver.

Finally, it may be expected that if glycogen was undergoing amylolytic degradation in the liver homogenate then the extent of this process should progressively increase with time. This expectation was not realized. Thus, a 10 per cent rat-liver homogenate was prepared and kept at 0° C. At five different time-intervals up to 15 min., aliquots were removed and the glucosyl oligosaccharides were determined. The concentration of this material (125 mgm. per cent) was unchanged during the course of this experiment.

On the other hand, the evidence does not rule out the possibility that in the intact animal, glucosyl oligosaccharides may result from the physiological action of liver amylase. If this is the case, the extent of this process is much greater than expected and its control by the physiological influences examined here would represent facts, unemphasized hitherto if they were known at all.

It is regarded as significant that the liver contains an amylomaltase[7] which synthesizes maltotriose and maltotetraose from maltose. The role of this series of compounds is understood in the carbohydrate metabolism of plants. They function as primers in the synthesis of polysaccharide catalysed by plant phosphorylase[8-12]. On the other hand, glucosyl oligosaccharides may be intermediates in glycogen synthesis if one considers the case where a trisaccharide (not a substrate) speeded up dextran synthesis catalysed by cell-free extracts of *Aspergillus niger* by serving as a glucosyl acceptor[13].

The implication of the above findings is that glucosyl oligosaccharides (no matter what their origin) may enter somewhere into the mechanism of glycogen synthesis. In this connexion, it is of interest that Beloff-Chain[14] has observed the presence of maltose, maltotriose and maltotetraose in rat diaphragm exposed to glucose labelled with carbon-14. Synthesis of oligosaccharides and glycogen from glucose but not glucose-1-phosphate was stimulated by insulin. Certainly the findings of Beloff-Chain on rat diaphragm resemble the present observations in rat liver.

We are satisfied from the results presented that the presence of glucosyl oligosaccharides in liver homogenate is not due to artefact. The exclusion of this explanation brings us face to face with the questions of their origin and of their possible significance in the metabolism of liver glycogen. These are deserving of further experimental study.

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INHIBITION AND ACTIVATION OF POLYNUCLEOTIDE PHOSPHORYLASE THROUGH THE FORMATION OF COMPLEXES BETWEEN ACRIDINE ORANGE AND POLYNUCLEOTIDES

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ACRIDINE orange reacts with the bases of polyadenylic acid to form a spectrophotometrically distinct complex (complex I) with an absorption peak at 465 mμ [1] (see Fig. 1). We have also discovered, however, that with an excess concentration of polymer (ratio of bases to dye 100 : 1) complex I disappears and is replaced by a second complex, II, with an absorption peak at 502 mμ associated with strong fluorescence in the green (Table 1). Treatment of polyadenylic acid with formalin, which blocks the formation of complex I [1], does not prevent the formation of complex II. The addition of magnesium reduces the concentration of complex II (see inset *B* of Fig. 1) and increases the concentration of complex I. Magnesium has no effect on the formation of complex I at nucleotide–dye mole ratios of 1 : 1 or less[1]. Low concentrations of sodium hydroxide (3×10^{-4} *M*) abolish complex I, but do not affect complex II ; high concentrations of sodium hydroxide (3×10^{-3} *M*) abolish complex II and free the dye in its alkaline form with an absorption peak at 440 mμ. In view of the insensitivity of complex II to formalin treatment and of its sensitivity to magnesium we conclude that acridine orange can be bound by the phosphate groups of polyadenylic acid as well as by the purine bases. The affinity of the phosphate groups for the dye is considerably greater than that of the purine base. A competition exists between

magnesium and acridine orange for the phosphate groups ; another competition exists between hydroxyl ions and phosphate groups for the dye, which has a pK of approximately 10·1.

Alkaline degradation of polyadenylic acid results in a transient increase in the amount of complex II formed with acridine orange followed by a gradual drop to zero (see inset *A* of Fig. 1). In view of the stoichiometry of the complex II reaction and the transient increase during hydrolysis, it appears likely that the dye is bound preferentially to the secondary terminal phosphates. Phosphorylysis of polyadenylic acid with polynucleotide phosphorylase shows no transient increase, but a gradual decrease in the amount of complex II formed. The former is consistent with a random splitting of the inter-nucleotide bonds ; the latter is consistent with a splitting of the terminal internucleotide bonds. These results also indicate no stereospecificity towards the 3′- or 5′-secondary phosphates.

Complexes I and II are also formed with ribonucleic acid isolated from *M. lysodeikticus*, but there

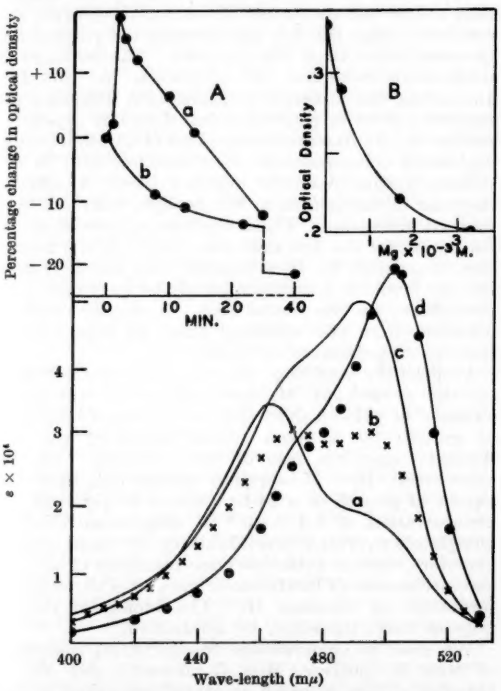

Fig. 1. Absorption curve of acridine orange (10^{-5} *M*) and its complexes at *p*H 7·0 in 0·017 *M* phosphate buffer. Curve *a*, complex I with polyadenylic acid ($1·9 \times 10^{-5}$ *M*); *b*, complex I with ribonucleic acid ($7·2 \times 10^{-5}$ *M*); *c*, free acridine orange; *d*, complex II with polyadenylic acid (9×10^{-3} *M*); closed circles, complex II with deoxyribonucleic acid ($4·9 \times 10^{-3}$ *M*). (Concentrations recorded as total organic phosphate.)

Inset *A* : *a*, per cent change in optical density at 500 mμ of complex II with polyadenylic acid during alkaline hydrolysis of the polymer at 100° in 3×10^{-2} *M* sodium hydroxide ; *b*, per cent change in optical density at 500 mμ of complex II with polyadenylic acid during phosphorylysis by polyase in $2·7 \times 10^{-2}$ *M* dipotassium hydrogen phosphate, *p*H 9·0, $5·4 \times 10^{-4}$ *M* magnesium chloride, 37°. Colour test : 0·5 ml. of polyadenylic acid solution, 0·5 ml. 0·01 *N* sodium hydroxide, 1·0 ml. water, 1 ml. $2·91 \times 10^{-5}$ *M* acridine orange.

Inset *B* : decrease in concentration of complex II with polyadenylic acid with increasing concentrations of magnesium. Optical density recorded at 500 mμ. Reaction mixture contained 0·017 *M* phosphate buffer, *p*H 7·0, $2·1 \times 10^{-4}$ *M* polyadenylic acid, 10^{-5} *M* acridine orange and magnesium chloride

Table 1. Effect of Deoxyribonucleic Acid (DNA) and Polyadenylic Acid (Poly A) in large Excess upon the Absorption Spectrum and Fluorescence Intensity of Acridine Orange
The solvent is 0·01 *M* sodium acetate, 0·5 *M* potassium chloride, *p*H 6·6

Dye conc. × 10^{-5} *M*	Material added	Concentration	Optical density, $\lambda = 500$ mμ	Relative fluorescence intensity, $\lambda_a = 490$ mμ $\lambda_b = 500$ mμ
3·3	none	—	0·089	1·0
3·3	poly A	$1·41 \times 10^{-3}$ *M* (AMP units)	0·101	2·2
3·3	HCHO-poly A	$1·41 \times 10^{-3}$ *M*	0·101	2·2
5·0	none	—	0·245	1·0
5·0	DNA	3×10^{-4} mgm./ml.	0·260	1·3
5·0	DNA	6×10^{-4} mgm./ml.	0·269	1·4
5·0	DNA	0·45 mgm./ml.	0·296	2·9

is no sharp separation between the appearances of complexes I and II as the concentration of ribonucleic acid is increased. Similar observations have been made with the copolymer, polyadenylic uridylic acid. This reflects the much higher ratio of secondary phosphate groups to the adenine and cytidine bases in the low molecular weight ribonucleic acid and the low adenine content in the co-polymer.

Complex II is also formed with deoxyribonucleic acid. (This excludes the 2′-hydroxyl groups of the polyribonucleotides.) The absorption spectrum of the deoxyribonucleic acid complex II is almost identical with that of polyadenylic acid. No evidence for complex I with deoxyribonucleic acid has been obtained with either native or alkaline denatured material. The green fluorescence of nuclei stained with acridine orange observed by Armstrong and Niven[2] is, no doubt, the result of the formation of complex II with deoxyribonucleic acid. The red fluorescence (phosphorescence ?) reflects the formation of a mixture of complexes I and II with ribonucleic acid. The deoxyribonucleic acid complex II is probably the same deoxyribonucleic acid-dye complex described by Peacocke and Skerrett[3] for other dyes of the acridine series. The failure of deoxyribonucleic acid to form complex I provides a potentially highly specific and sensitive method for determining deoxyribonucleic/ribonucleic acid ratios in nucleic acid mixtures. Moreover, if the non-reactivity of the 6′-amino-groups of deoxyribonucleic acid is a function of its double helical structure, then it would appear likely that ribonucleic acid is a single helix.

Alkaline hydrolysis of ribonucleic acid abolishes its ability to form complexes I and II. Boiling deoxyribonucleic acid in 0·05 *N* sodium hydroxide for 1 hr. has no effect on its ability to form complex II. Adenosine 5′-phosphate and adenosine diphosphate at concentrations of 10^{-3} *M* do not form complex II with acridine orange. The proteins, lysozyme and albumin, do not form complexes I or II. Methylene blue forms analogous complexes I and II with the respective absorption peaks at 600 and 670 mμ. Complex II is not sensitive to alkali, reflecting the fact that methylene blue does not possess a pK in the alkaline region.

The rate of synthesis and phosphorylysis of polyadenylic acid by polyase is inhibited by acridine orange. This can be reversed by increasing the concentration of magnesium (Table 2), even under conditions in which magnesium itself becomes progressively inhibitory. The curve of the rate of polymerization versus adenosine diphosphate concentration has a slope independent of the concentration

Table 2. Effect of Concentration of Magnesium on the Inhibition by Acridine Orange of the Rate of Synthesis of Polyadenylic Acid

Rate recorded as moles of inorganic phosphate released $\times 10^{-8}$ in 20 min., temp. 37°, *tris* buffer, 0·017 *M*, *p*H 9·5, $6{\cdot}35 \times 10^{-4}$ *M* adenosine diphosphate, $5{\cdot}8 \times 10^{-5}$ *M* acridine orange, 0·17 *M* potassium chloride

Magnesium $\times 10^{-4}$ *M*	3·33	6·67	10·0	13·3	16·7
Control	21·6	19·7	18·0	16·7	15·5
Inhibited	14·1	13·6	13·1	12·8	12·1
Difference	7·5	6·1	4·9	3·9	3·4
Per cent inhibition	35	29	27	22	21

Table 3. Effect of Concentration of Adenosine Diphosphate (ADP) on the Inhibition by Acridine Orange of the Rate of Synthesis of Polyadenylic Acid

Experimental conditions are the same as in Table 2. $3{\cdot}3 \times 10^{-4}$ *M* magnesium chloride

ADP $\times 10^{-4}$ *M*	1·25	1·88	3·15	6·25	9·4	12·5
Control	5·27	7·5	10·6	16·4	20·4	23·3
Inhibited	2·15	3·5	7·1	12·9	16·6	19·8
Difference	3·12	4·0	3·5	3·5	4·3	3·5
Per cent inhibition	59	49	33·3	21·5	20·6	15

Table 4. Effect of Poly A Concentration on the Inhibition by Acridine Orange of the Rate of Phosphorylysis of Polyadenylic Acid

Rate given in arbitrary units, temp. 37°, *p*H 8·5, 0·07 *M tris*, 0·02 *M* phosphate, $1{\cdot}4 \times 10^{-4}$ magnesium chloride, $1{\cdot}25 \times 10^{-4}$ acridine orange, 0·14 *M* potassium chloride

Poly A $\times 10^{-4}$ *M* (AMP units)	0·88	1·74	3·47	6·95	13·9*
Control	77	92	103	112	93
Inhibited	0	0	54	71	68
Difference	77	92	49	42	25
Per cent inhibition	100	100	48	37	27

* Separate experiment

of acridine orange. Thus a fixed drop in the polymerization-rate occurs which is independent of the substrate concentration (Table 3). Nevertheless, the per cent inhibition decreases with increasing substrate concentration. A similar relationship exists between the rate of phosphorylysis of polyadenylic acid and its concentration (Table 4). However, there are both relative and absolute decreases in inhibition by acridine orange.

These findings indicate that acridine orange inhibits by forming a complex with the polymer, presumably complex II. The constant drop in the rate of polymerization in the presence of acridine orange is consistent with the previous conclusion[4] that the rate-determining parameter in the polymerization process is the concentration of the polymer molecules, of which a fixed quantity is removed for a given concentration of acridine orange. Moreover, these results also appear to show that this enzyme system is able to synthesize additional polymer molecules, the concentration of which is proportional to the initial concentration of adenosine diphosphate. Further evidence for this has been obtained by observing an increase in the concentration of complex II formed during the polymerization process with increasing concentrations of adenosine diphosphate or enzyme and with time. At low ionic strength the inhibition by acridine orange of polymerization can be reversed by the addition of polyadenylic acid. A similar effect is observed with the contaminating ribonucleic acid of the enzyme preparations.

Under conditions in which the quantity of ribonucleic acid contamination of the reaction mixture is low and the ionic strength relatively high, varying the concentration of salt, which has been found to vary the Michaelis constant[5,6], has no effect on the per cent inhibition by the dye but does cause an absolute change in the rate of polymerization (Table 5). This indicates that ionic strength influences the

Table 5. Effect of Potassium Chloride Concentration on the Inhibition by Acridine Orange of the Rate of Polymerization of Polyadenylic Acid

Experimental conditions the same as in Table 2. $3{\cdot}3 \times 10^{-4}$ *M* magnesium chloride

Potassium chloride $\times 10^{-2}$ *M*	1·67	3·3	5·0	6·67	8·35
Control	25·2	31·8	34·0	38·0	37·0
Inhibited	16·1	20·7	23·4	23·7	22·8
Difference	9·1	11·1	11·6	14·3	14·2
Per cent inhibition	36·4	35	31·3	40	38

polymerization reaction but does not affect the rate or extent of synthesis of primer. Other studies have shown that increasing potassium chloride concentrations strongly activate the rate of phosphorylysis of polyadenylic acid by polyase[7]. Thus far, no evidence of a disproportionation between the rate of polymerization and phosphorylysis of polyadenylic acid has been obtained with various purified fractions of the enzyme, which would suggest the presence of a primer synthesizing enzyme in addition to a polymerizing enzyme[7,8].

The above picture is complicated by the finding that at low concentrations of potassium chloride and acridine orange the dye can increase the polymerization-rate more than 100 per cent. The addition of magnesium enhances the activation by the dye. Increasing the substrate concentration decreases the relative extent of activation but does not appear to reverse it. At fixed concentrations of acridine orange increasing concentrations of ribonucleic acid in the polymerization reaction mixture cause a marked decrease in the inhibition by the dye, followed by a marked activation. These findings suggest that the activation by the dye may occur through the formation of complex I. It is possible that the activation process involves neutralization of the internucleotide phosphates by the bound dye. A similar result is obtained from the shielding effect of high concentrations of potassium chloride.

Preliminary studies of the effect of acridine orange on the growth of *M. lysodeikticus* in submerged cultures[9] at *p*H 8·5 show that the extent of inhibition of growth by a given concentration of the dye depends upon the size of the inoculum. In one experiment 10^{-7} *M* acridine orange inhibited the extent of growth of a 24-hr. culture 40 per cent. A concentration of $1{\cdot}4 \times 10^{-4}$ *M* magnesium chloride completely overcame this inhibition. It would appear, therefore, that at sublethal concentrations of the dye the mechanism of inhibition of growth is through the formation of complex II. The biological role of polyase may, therefore, be implicated.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Preparation of Block and Graft Copolymers in Systems where the Life-time of the Kinetic Chain is Long

WE have reported[1] that block copolymers may be prepared by adding methyl methacrylate to a latex of polyvinyl acetate prepared by gamma-irradiation of the monomer emulsion. Polymer radicals trapped in latex particles initiate polymerization of the second monomer, forming linear block copolymer molecules.

It is apparent, however, that more copolymer is formed than can be accounted for by this mechanism. Latexes prepared from 1 gm. of vinyl acetate containing of the order of 10^{16} latex particles should, following the arguments of Smith and Ewart[2] that half the particles contain live radicals, give a yield of block copolymer of approximately 2 mgm. In fact these latices have been found to yield 0·05–0·10 gm. of copolymer per gram of vinyl acetate together with large excesses of methyl methacrylate polymer.

During the polymerization of the second monomer no further radicals are generated, the propagating radicals remain trapped in the latex particles and so mutual termination reactions do not occur. The kinetic chain-length is thus essentially limited only by the amount of methyl methacrylate added. The molecular weight of the polymer molecules is, of course, limited by chain transfer reactions. During the course of the polymerization of a gram of methyl methacrylate by 10^{16} radicals, transfer to monomer and polymer must occur many times. Transfer to monomer will account for the pure polymethyl methacrylate found in the system. Transfer to polyvinyl acetate will lead to branched graft copolymer molecules which must form the preponderant part of the copolymer yield.

Transfer-limited molecules may also be obtained by adding styrene emulsions to previously irradiated polymethyl methacrylate films. Small amounts of block copolymer are found in the film, but the bulk of the polymerization occurs in the supernatant styrene emulsion. The characteristics are essentially similar to a true emulsion polymerization. The rate is given by $k_p n[M]$, where k_p is the propagation constant for styrene, $[M]$ the monomer concentration and n varies between the number of latex particles formed and half that number. The temperature increment of the rate is 7·2 kcal., which is close to the energy of activation of propagation for polystyrene. The molecular weight of the polystyrene is exceptionally high, measurements of viscosity indicating a range of $4–12 \times 10^6$. The samples of higher molecular weight have high Huggins constants[3] and are probably highly branched.

Our suggestion is that polymerization proceeds in the polymer film until such time as transfer to monomer occurs and the resulting small radicals escape into the supernatant phase and initiate emulsion polymerization of styrene. The size of the polystyrene formed is, to a large extent, limited only by transfer. The measured molecular weights are in fact in excess of the limit to the number average set by the monomer transfer constant, but a dead polymer molecule can resume growth as a branched molecule if another radical is transferred to it.

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[1] Allen, P. E. M., Downer, J. M., Hastings, G. W., Melville, H. W., and Urwin, J. R., *Nature*, **177**, 910 (1956).
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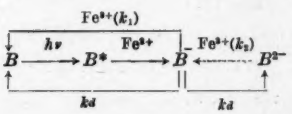
Photo-reduction of Methylene Blue and Thionine by Ferrous Sulphate using Flash Irradiation

WHEN dilute solutions of methylene blue in 0·1 *N* sulphuric acid are subjected to flash photolysis with orange-red light in the presence of ferrous sulphate ($\sim 0{\cdot}1\ M$), the kinetic curves obtained by monitoring at various wave-lengths can all be interpreted in terms of the following reaction scheme:



By direct measurement, the rate constant (k_d) for the dismutation of the semiquinone radical (B^-) was found to be of the order $1{\cdot}5 \times 10^9$ l. mole^{-1} sec.$^{-1}$. By observing the degree to which the formation of leuco methylene blue (B^{2-}) was suppressed by the addition of ferric iron, the value of k_1/k_d and hence k_1 ($\sim 2{\cdot}4 \times 10^5$ l. mole^{-1} sec.$^{-1}$) was obtained. The latter is so much smaller than k_d that the quantity of ferric iron produced by the photochemical reaction has no appreciable effect on the dismutation of the semiquinone radical.

The reverse of the dismutation reaction, if sufficiently rapid, would lead to an appreciable equilibrium concentration of semiquinone in partly reduced methylene blue solutions. This would allow of two routes for the re-oxidation of the leuco-base, namely, by direct reaction with ferric iron, or by reaction of ferric iron with the equilibrium concentration of semiquinone. Rough observations of the rate of re-oxidation, taken in conjunction with the above value for k_1, suggest that the equilibrium concentration of semiquinone must be very much less than the value reported by Michaelis and co-workers[1] for dilute acid solutions.

In view of the observations of Bridge and Porter[2,3], it is of particular interest to determine whether the semiquinone in the present experiments is produced via the triplet state or by direct reaction of the excited singlet state. This point has been investigated with thionine, the behaviour of which on flash photolysis is qualitatively similar to that of methylene blue. If the semiquinones were formed solely by reaction of the excited singlet states of the dyestuffs, the quenching of fluorescence by ferrous sulphate should be related to the yield of semiquinone by the expression:

$$\frac{\varphi_\infty}{\varphi} = 1 + \frac{1}{K[\mathrm{Fe}^{2+}]}$$

where φ_∞ refers to the yield of semiquinone in the presence of a large excess of ferrous iron, and K is the normal Stern–Volmer fluorescence quenching constant (K is of the order 1 l. mole^{-1} for thionine under the conditions of experiment). With thionine the above relationship is not obeyed. The yield of thionine semiquinone rises to 50 per cent of its maximum value within the range $[Fe^{2+}] = 10^{-3}$–10^{-2} M, where the stationary concentration of triplet is decreasing rapidly. Since 50 per cent quenching of fluorescence is only reached at $[Fe^{2+}]$ in the region of 1 M, it appears that direct reaction of the singlet excited state is very small at the lower concentrations of ferrous iron, and in the latter region therefore the semiquinone must originate from some other source, presumably the triplet state. It is possible that the semiquinone is formed from the excited singlet state also, at the high concentrations of ferrous iron required to quench fluorescence.

The work with thionine and methylene blue is being continued and will be reported in detail elsewhere.

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Spectrophotometric Determination of Protein in Alkaline Solution

This method for the spectrophotometric determination of protein in alkaline solution was developed in order to determine the protein of *Chlorella* cells. It was not possible to obtain *Chlorella*-cell protein, readily, in acid solution. It was possible to break most of the cells by grinding mechanically with silica sand but this method is tedious and time-consuming. The latter point is important when it is necessary to measure physiological changes which proceed at a rapid rate.

Total protein was measured by the Folin phenol reagent[1] with a Zeiss spectrophotometer (Type *PMQ*II). All compounds which contain peptide bonds give a colour reaction and are measured by this method, but the actual figures obtained were based on total nitrogen as determined by the Kjeldahl technique. Kjeldahl nitrogen was converted to protein by using the usual factor of 6·25 (ref. 2).

The reagents used in the spectrophotometric method were:

(*A*) 2 per cent sodium carbonate in 0·1 N sodium hydroxide.

(*B*) 0·5 per cent crystalline copper sulphate ($CuSO_4.5H_2O$) in 1 per cent sodium or potassium tartrate (which was freshly prepared because complex salts were precipitated after standing for about an hour).

(*C*) Alkaline copper solution (1 ml. of reagent *B* was mixed with 50 ml. of reagent *A*. This solution was discarded after one day).

(*D*) Folin reagent diluted with water, 1:1 (this is the phenol reagent of Folin and Ciocalteu, manufactured by Bayer, West Germany).

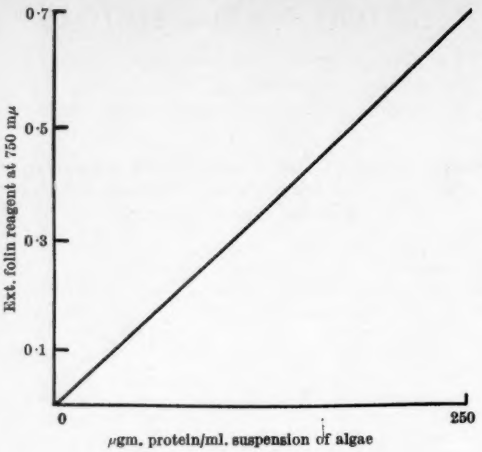

Fig. 1. Calibration curve

The experimental procedure was as follows: 5 ml. of an algal suspension was placed in a 15-ml. centrifuge. The cells were centrifuged, washed, 5 ml. of 1 N sodium hydroxide was added and the whole placed in a boiling water-bath for 10 min. (It was found that on boiling for longer periods of time there was no significant increase or decrease in the protein extracted.) The contents of the tube were centrifuged and the sodium hydroxide extract added to 5 ml. of water. The diluted extract was thoroughly mixed and 1 ml. taken and added to 5 ml. of reagent *C* and allowed to stand for 10 min. 0·5 ml. of the diluted Folin–Ciocalteu reagent was mixed with this solution and after 40 min. the extinction of the solution was measured at 750 mμ. A control blank was always used and the results were calculated as μgm. protein per ml. of algal suspension from the calibration curve (Fig. 1). With duplicate samples the error was within 5 per cent.

This work was carried out at the University of Marburg, West Germany.

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Spectrophotometric Determination of Total Carbohydrate

The colour reaction given by anthrone reagent was used for the determination of carbohydrates by a spectrophotometric method. The method used is based on those of Fales[1] and Schlegel[2] but was considerably modified. For example, Schlegel used a wave-length of 570 mμ in order to correct for the presence of pigments in the plant material. But in the technique described here, a blank containing only the plant material (for each determination) and sulphuric acid were used. It was therefore possible to measure the carbohydrate content of the plant material (in this case *Chlorella* cells) at different

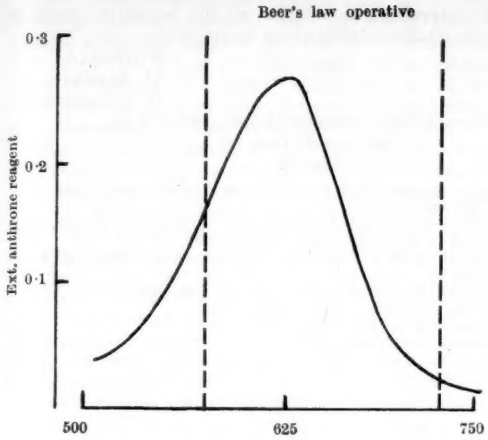

Fig. 1. Extinction of anthrone reagent

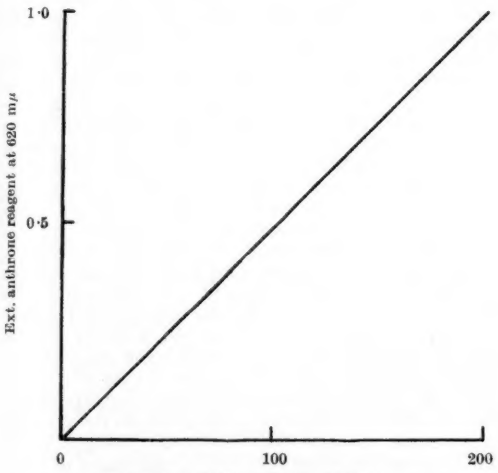

Fig. 2. Calibration curve

stages of growth and when the cells contained different amounts of chlorophyll. Nevertheless, a small but constant error, due to the colour of the anthrone reagent itself, is always present.

The reagent consisted of 0·2 gm. anthrone, 8 ml. absolute alcohol, 30 ml. water, and 100 ml. concentrated sulphuric acid (specific gravity 1·84).

A small volume of algal suspension was diluted five times and to 1 ml. of this suspension 10 ml. of anthrone reagent was added. This was then placed in a boiling water-bath for 7 min. and cooled immediately afterwards. The extinction was measured at 620 mμ (Fig. 1) and the amount of total carbohydrate expressed in μgm. glucose per ml. suspension by using a calibration curve (Fig. 2). A high ratio of reagent to suspension (10 : 1) was necessary because lower ratios did not give a straight-line relationship. The error involved in duplicate samples was less than 8 per cent. This work was carried out at the University of Marburg, West Germany.

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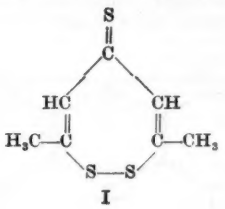
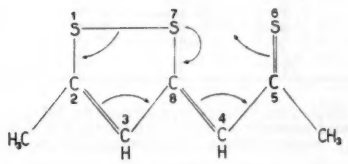
Thio-Thiophthen : an Unusual New Type of Aromatic System

In the present communication we report our preliminary findings in researches on a series of sulphurated cyclic compounds, carried out jointly with G. Traverso of the Physical Chemistry Institute of the University of Pavia.

Arndt *et al.*[1] gave formula I for a compound obtained by treating diacetyl-acetone in benzene solution with phosphorus pentasulphide. From X-ray analysis, we have deduced formula II.



I



II

This structure is characterized by no-bond resonance, which confers an aromatic character on the two rings in full agreement with the properties of the substance[2]. We propose to name this condensed ring system 'thio-thiophthen'.

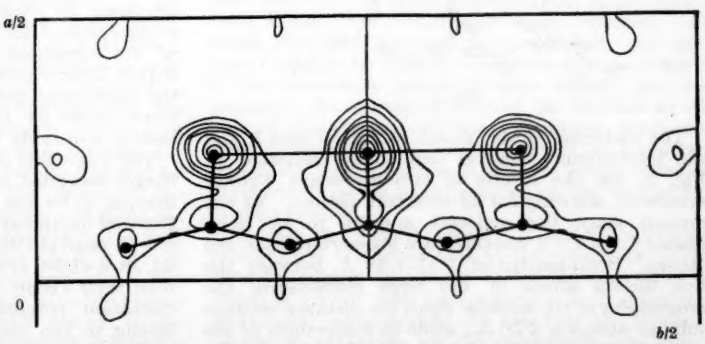


Fig. 1. First electron density projection on (001) : Sayre's equation gave 43 on 68 terms. The indicated positions of atoms are from the first Fourier summation allowing for all structure factors

The substance, prepared by G. Traverso, was crystallized from *tert.* butyl alcohol as thin rectangular or rhomboidal plates. Single-crystal precession and Weissenberg photographs showed an orthorhombic system, space group *Pnma*, with a, 7·80; b, 20·10; c, 5·36 A. and 4 molecules in the unit cell. Observed density, 1·47; calculated, 1·48. Tests of centrosymmetry[3,4] were used to exclude space group $Pna2_1$. Four molecules in the space group *Pnma* require the central sulphur atom and the C_8 atom to be in a special position on the mirror plane at $y = 1/4$.

Every attempt to make the Arndt structure (I) agree with our experimental results, by means of Patterson and Fourier analysis, gave negative results. We succeeded, however, with methods which did not make any assumption about the configuration of the molecule.

Using the Sayre–Cochran–Penfold method[5] we were able to fix the position of atoms, with a reliability index $R = 0·29$ for $hk0$ reflexions and 0·41 for reflexions $0kl$.

Luzzati's error-curve[6] has confirmed these results, indicating a mean error in the co-ordinates of about 0·10 A. in the first case, and 0·08 A. in the second. Further, the Buerger 'minimum function' method[7] gave maps which agree fully with the previous ones.

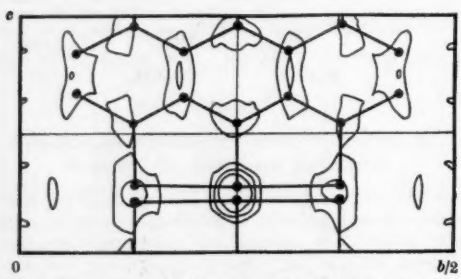


Fig. 2. Buerger's map of the minimum function M_4 (yz) on (100). The indicated positions of atoms are from the first Fourier summation allowing for all structure factors

In Figs. 1 and 2 respectively electron-density maps for the plane (001), calculated by Sayre's equation, and for plane (100), obtained by the Buerger method, are shown.

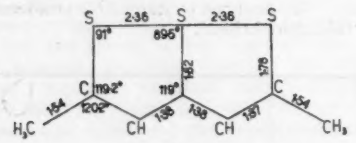


Fig. 3

The molecular shape, shown in Figs. 1 and 2, and the interatomic distances and angles indicated in Fig. 3, are the results of two successive Fourier syntheses, allowing for all structure factors. At the present stage the molecule appears to be quite planar; the C—S distances are less certain than the others. Bond-lengths of 1·37–1·38 A. between the five carbon atoms of the rings characterize the aromaticity of the nucleus. Since the distance between sulphur atoms is 2·36 A., while in compounds of the type[8] R—S—S—R it is 2·04 A., the S—S bond order is less than unity. The linear system S—S—S is also interesting in relation to the transition state of nucleophilic substitutions to sulphur[9].

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The Electron Affinity of Atomic Oxygen

In a recent communication, Morris and Schmeising[1] applied the empirical extrapolation of ionization potentials of isoelectronic ions to determine the binding energy of the O^- ion (the atomic oxygen electron affinity). By extending the order of the extrapolation through eight isoelectronic ions (to S^{7+}), they find a slightly higher value, 1·044 eV., than is found from the more usual quadratic extrapolation. Stating that experimental determinations of the electron affinity have given results in unresolved conflict, Morris and Schmeising refer to three discordant values. A value of about 2·2 eV. was obtained by a thermodynamic evaluation of the probability of attachment of electrons to atomic oxygen at a hot filament, and from electron impact studies undertaken originally to determine the dissociation energies of molecular nitrogen and carbon monoxide. The value of 1·48 eV. is given by the optical threshold for photodetachment from O^- by Smith and Branscomb. The value of 1·05 eV., which coincides with Morris and Schmeising's extrapolation, was obtained by Schüler and Bingel from the analysis of a certain discrete band spectrum thought to be due to a transition between two bound states of OH^-. (For the original references see Morris and Schmeising[1].) My purpose here is to resolve these apparent ambiguities.

The electron impact experiments referred to by Morris and Schmeising are not now in general in conflict with the photo-detachment value, providing the correct values of the relevant dissociation energies are used in their interpretation. Hagstrum has re-interpreted[2] his results to show the good quality of the agreement. The most precise values for EA(O) from electron impact experiments are from the appearance potentials of zero-energy ion pairs in nitric oxide by Clarke[3] (1·47 ± 0·05 eV.) and in carbon monoxide by Lagergren[4] (1·42 ± 0·05 eV.).

The low value of EA(O) obtained by Schüler and Bingel depended on the analysis of a band spectrum thought to be due to OH^-. Afterwards, Barrow and Downie[5] produced evidence that the spectrum was due to neutral OH. Schüler and Michel[6] later found an ultra-violet system involving a state in common with their visible system, and both its analysis and excitation potential prove that the two systems belong to the neutral molecule. The observations of Schüler *et al.* have, therefore, no relevance to the properties of O^-.

The photo-detachment experiments on O^- have recently been improved[7], with the result that the optical threshold at 8460 ± 30 A. for the transition $O^- \ ^2P_{1/2} \rightarrow O \ ^3P_2 + e$ corresponds to a physical electron affinity of 1·465 ± 0·005 eV., or 33·80 ± 0·12 kcal./mol. The observations of the spectrum are direct and its interpretation unambiguous.

Since the submission of the reply by Morris and Schmeising to these comments, I have re-examined the results of Metlay and Kimball (which gave 2·3 eV. from attachment at a hot filament) in an effort to explain the remaining discordant experimental value for EA(O). Metlay and Kimball obtained their result from the solution of Saha's equation for EA(O) at each of a number of fixed values of pressure (of nitrous oxide) and temperature (of the tungsten filament). They assumed that O^- from the nitrous oxide was the ion which produced the measured current of negative ions. However, if one deduces the affinity of the ion (whatever it may have been) from the reciprocal dependence on temperature (at fixed pressure) of the logarithm of the ratio of currents of electrons and negative ions, one obtains straight-line plots the slopes of which give 3·7–3·8 eV. An impurity with an affinity of 3·7 eV. need only have had a fractional concentration of 6×10^{-4} in the nitrous oxide for the value of 2·3 eV. to have been obtained. The influence on this dependence on temperature of the O^- ions (with an affinity of 1·465 eV.) would be entirely negligible. The possibility that the nitrous oxide was contaminated with 0·06 per cent chlorine is suggested by (*a*) the value of the affinity obtained from the dependence on temperature, (*b*) the fact that Metlay and Kimball used 98 per cent pure commercial nitrous oxide purified by distillation, and (*c*) the common commercial processes for production of nitrous oxide generate small quantities of chlorine not easily removed by fractional distillation because of the similar boiling points of the two gases. This suggestion requires experimental proof by mass spectrometry, but it is evident that the data of Metlay and Kimball are internally consistent only if one supposes that the ion observed had a large affinity and small concentration.

The empirical extrapolation methods for finding electron affinities have recently been reviewed[8]. It was found that, of these methods, extrapolation through an isoelectronic sequence of the first excited configuration, proposed by Bates, is the most successful for the elements from boron to fluorine and aluminium to chlorine. However, none of the methods rests on any real theoretical justification for extension from neutral atoms and positive ions, the valence electrons of which move in coulomb fields, to negative ions, where these fields are of short range. Furthermore, the empirical extrapolations are most useful for interpolating the affinities of aluminium, silicon and phosphorus, by arbitrarily adjusting the predictions to agree with the known affinities of carbon, oxygen, fluorine, sulphur and chlorine, for each extrapolation method gives results in error by about 0·5 eV. for these ions. For example, the Glockler extrapolation, used by Morris and Schmeising, when applied to fluorine and chlorine gives 2·93 and 3·05 eV., respectively, and this result is almost independent of the order of the extrapolation. But these values are about 0·7 eV. lower than the known affinities of these gases. If one adds 0·7 eV. to the oxygen affinity predicted by the Glockler extrapolation in quadratic form (that is, interpolating EA(O) from fluorine and chlorine) one finds 1·4 eV., in reasonable agreement with the photodetachment results (1·465 eV.). However, the same correction applied to the quadratic Glockler extrapolation for sulphur 'corrects' the affinity from 2·07 eV. to 2·8 eV., while the photodetachment value for EA(S) is, by coincidence, just 2·07 eV. Furthermore, Geltman[9] has shown that for some atoms the predictions of the Glockler method are strongly dependent on the order of the extrapolation, and the nature of this dependence varies radically from element to element. Thus, since the extrapolation methods rest on an uncertain theoretical basis, the answer to the question which method is best may require experimental values for so many of the ions that the value of empirical methods for prediction is greatly reduced.

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Branscomb has provided further results in support of a figure of about 1·465 eV. for the first electron affinity of atomic oxygen $E(O \rightarrow O^-)$, and there is strong evidence for this value. However, the difference between this result and the value of Metlay and Kimball[1], $E(O \rightarrow O^-) = 2{\cdot}33$ eV., obtained from electron attachment at a hot filament, still has to be accounted for. In addition, various extrapolation methods[2] give rather lower values than 1·465 eV. for the first electron affinity of oxygen. For example, the extrapolation procedure used by us yielded $E(O \rightarrow O^-) = 1{\cdot}044$ eV., and it seems appropriate to make some comments on this procedure.

The technique employed by us is a development of that due to Glockler[3] and assumes that the ionization potentials I of isoelectronic ions satisfy a function $f(Z)$ of the atomic number Z which is continuous and well behaved. A major disadvantage of the procedure is that the results essentially represent very small differences between large numbers, and they may therefore be subject to considerable uncertainty if the ionization potential data utilized are not accurate. In our application of the method to the case of the electron affinities of oxygen, there was some doubt as to the values of some of the ionization potentials, and the electron affinity values obtained appeared to be the most probable on the basis of the original premise.

To test the general validity of the extrapolation procedure it is applied here to the estimation of the electron affinity of atomic hydrogen, the value of which is known with high accuracy from quantum-mechanical calculations[4]. In this case the requisite ionization potentials for the estimation are known with high precision. The values quoted by Moore[5]

Table 1. Ionization Potentials of Ions Isoelectronic with H–

Z	Ion	Ionization potential (I) Moore	Selected value
2	He	24·580	24·580
3	Li^+	75·6193 ± 0·0031	75·6193
4	Be^{++}	153·850 ± 0·012	153·850
5	B^{+++}	259·298 ± 0·025	259·298
6	C^{++++}	391·986 ± 0·037	391·986
7	N^{+++++}	551·925 ± 0·062	551·9336
8	O^{++++++}	739·114 ± 0·074	739·157

are listed in col. 3 of Table 1 together with their probable errors. If the data in col. 3 are extrapolated to $Z = 1$, the result for the electron affinity of hydrogen $E(H \rightarrow H^-) = 0{\cdot}7198$ eV. is obtained. However, a difference table shows some 'noise' which may be removed by smoothing the second differences somewhat. Working both ways from the column of smoothed second differences, one can obtain the data listed in col. 4 of Table 1, and extrapolation yields $E(H \rightarrow H^-) = 0{\cdot}7092$ eV. This is in excellent agreement with the value of about 0·71–0·75 eV. obtained by quantum-mechanical calculations. This agreement shows that the premise concerning f(Z) is correct in this case.

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Oxidized Iodine in Sea Water

In *Nature* of August 3, 1957, p. 250, T. I. Shaw and L. H. N. Cooper suggested that the oxidized form of iodine in sea water is, in all probability, hypoiodous acid and is not iodate, as we believed[1]. We were interested in the reasons for their conclusion; but we cannot accept their view.

First, of three different reactions which determine theoretically the equilibrium of the system (I_2, I^-, IO^- and IO_3^-) in oxygenated sea water:

$$I_2 + OH^- \rightarrow I^- + IO^- + H^+ \quad (a)$$
$$3IO^- \rightarrow 2I^- + IO_3^- \quad (b)$$
$$I^- + \tfrac{1}{2}O_2 \rightarrow IO^- \quad (c)$$

they dismiss reaction (*b*) on the arbitrary assumption that the reaction may be slow because it is trimolecular; then they calculate the ratio hypoiodite/iodide to be unity.

Our experiments have shown that the reaction in question goes smoothly in the given conditions, whereas reaction (*c*) goes on with great difficulty, and, in practice, it can be ignored. Furthermore, experimentally we have reached the conclusion that there is no probability of hypoiodite being detected in sea water.

Table 1

Sample	Phenol added (ml.)	Sodium hydroxide added (ml.)	Iodide–iodine found (μgm. at./l.)	Oxidized-iodine found (μgm. at./l.)
1	0	0	0·15	0·21
2	3	0·5	0·15	0·21
3	6	1·0	0·15	0·21

Our experiments may be summarized as follows:

(*A*) Three different 200-ml. samples of the same sea water were treated with various amounts of 5 per cent phenol solution and 3 *N* sodium hydroxide solution, and were processed according to our method of iodine determination[2]. If the original sea water had contained hypoiodite, it would have been decomposed by the phenol treatment, giving a smaller value for the oxidized iodine[3]. The results in Table 1 show that, contrary to Shaw and Cooper, the oxidized iodine was not in the state of hypoiodite.

(*B*) 1 litre of a sea water sample was put in a stoppered bottle with iodine and shaken for 1 hr. (1) 20 ml. of the solution thus obtained was titrated with 1/500 *N* thiosulphate solution. The titre, which corresponds to free iodine and the hypoiodite formed from it, was 4·5 ml. Then the solution was acidified with 3 ml. of 3 *N* hydrochloric acid. Iodine was liberated and consumed an additional 1·0 ml. of the thiosulphate solution, which corresponds to iodate originating in hypoiodite. (2) Another 20-ml. portion of the solution was acidified and titrated; the thiosulphate solution consumed was 5·5 ml. (3) After the addition of potassium iodide, another 20-ml. portion was treated as in (2), and this required 5·5 ml. thiosulphate. (4) To another 20 ml., 2 ml. of a 5 per cent phenol solution was added: the orange colour of the solution disappeared. After 3 min. the solution was acidified with hydrochloric acid and the solution became tinged with yellow, pointing to the liberation of iodine, which consumed 1·0 ml. of the thiosulphate solution. It is evident that hypoiodite directly, and free iodine indirectly via hypoiodite, were removed by phenol, leaving untouched the iodate which first liberated iodine by acidification. (5) Another 20 ml. was treated with phenol and sodium hydroxide solution; this required 1·0 ml. of thiosulphate solution. (6) Portions were treated as in (1) after lapses of 1–25 days. With time, the amount of thiosulphate solution required for the first titration gradually decreases, with a corresponding increase in that required for the second titration. This shows that the velocity of reaction 3 $IO^- \rightarrow 2I^- + IO_3^-$ is high (see Fig. 1).

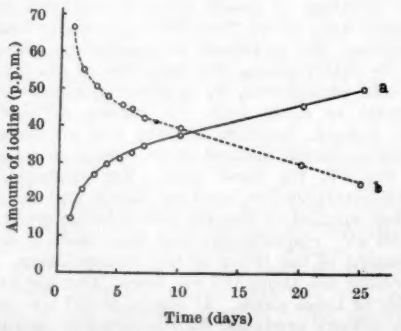

Fig. 1. (*a*) Iodate curve; (*b*) hypoiodite curve

Summarizing the experimental results: (1) there is no detectable amount of hypoiodite in sea water; (2) the system iodine, iodide, hypoiodite and iodate reaches a thermodynamical equilibrium rather quickly with iodide and iodate ions as predominant components; (3) even in the presence of oxygen, the oxidation of iodide to a higher oxidized state does not occur easily; otherwise iodate would be only one possible state of iodine in an oxygenated sea water. For reasons (2) and (3), iodine in sea water remains in practice in two states, namely, iodide and iodate.

Shaw and Cooper's view that the ratio of hypoiodite to iodide is unity is thus untenable: as a matter of fact, even if the values are limited to those of the off-shore waters of Honshu[1a], to which they refer, the ratio varies from 0·88 to 1·75 with an average of 1·43, a value which cannot be easily made unity in round figures when the accuracy of determination is taken into consideration. Furthermore, among our later results from other regions[1b], which were apparently not available to them when formulating their views, we find many extreme values such as, for example, those for the 0 m. sample from station Satsuma 29, lat. 03° 38′ N., long. 141° 56′ E., 0·00 μgm. atom iodate-iodine/litre and 0·06 μgm. atom iodide-iodine/litre with iodate-iodine/iodide-iodine = 0·00, while for the 0 m. sample from station Satsuma 5, lat. 13° 54′ N. and long. 150° 57′ E., iodate-iodine and iodide-iodine are respectively 0·21 μgm. atom/litre and 0·04 μgm. atom/litre, with the ratio iodate-iodine/iodide-iodine equal to 5·2.

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WINKLER[1] has demonstrated that a substantial part of the iodine naturally present in sea water is in an oxidized form which he considered to be iodate. I have suggested that the bactericidal nature of sea water towards coliforms is due to the presence of this iodate[2].

Shaw and Cooper[3] have recently published a communication on the mechanism of iodine oxidation in sea water in which they demonstrate thermodynamically that aerial oxidation of iodide would take place at the *p*H of sea water. They recognize that the thermodynamically stable form of oxidized iodine at this *p*H is iodate, but on the grounds of the third-order kinetics of the hypoiodite–iodate conversion, and the presence of biological activity, claim that iodate would not be formed. They consider that the oxidized form of iodine present would be an equilibrium mixture of iodine and hypoiodous acid (hypoiodite).

My work on the coast of New Zealand is not in agreement with these views, as the experimental evidence indicates that the oxidized form of iodine present in the local sea water is iodate, with no evidence for the presence of a detectable amount of hypoiodite. This experimental evidence is briefly as follows.

(*a*) Upon the addition of excess iodide to local sea water, a formation of the triiodide ion is not observed spectrophotometrically at 356 mμ, or by the formation of a blue colour with starch, unless the solution is, in each instance, first acidified. If, as according to Shaw and Cooper, the iodine was present as hypoiodite, then the above reactions would have been given without acidification. Solutions of iodate of equivalent concentrations to that found in sea water react only when acidified.

(*b*) When the amount of oxidized iodine is estimated as above, the concentration of oxidizing material found is too great to be other than iodate. In my earlier paper I showed that the amount of oxidizing material was equivalent to 150 μgm./litre of iodine, that is, the amount of iodate which would be formed from 25 μgm./litre of iodine, which is in agreement with the observations of Winkler[1] and others[4]. If this amount of oxidizing substance were hypoiodous acid or hypoiodite, then it would need to have been formed from 75 μgm./litre of iodine, which is more than is usually regarded as being present.

In the light of the above evidence I consider that the local sea water contains iodate. Sulphamic acid was used for the acidifications as it effectively prevents interference from nitrite.

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TAKEN together, Sugawara and Terada's experiment *A* and Johannesson's evidence form more cogent reasons for believing iodate to be the oxidized form of iodine in the sea than the reasons we presented for believing hypoiodous acid to be the oxidized form. However, as we indicated, the volatility of iodine from sea water seems to demand that a large part of the iodine should be in the form of hypoiodite. Unless the volatility can be explained quantitatively in terms of an iodate–iodide mixture, the state of iodine in the sea cannot be considered as satisfactorily settled.

Moreover, we find that whereas Sugawara and Terada's conclusions upon the rate of oxidation of iodide in the sea are doubtful, their conclusions upon iodide–iodate–hypoiodite equilibration have slender experimental foundation.

First, if iodide oxidation in the sea were as slow as Sugawara and Terada's laboratory experiment—and one that we have made—suggest, then we should expect that turbulent mixing would prevent variations in the amount of oxidized iodine between neighbouring portions of sea water. Sugawara[1], however, has presented results showing that the amount of oxidized iodine varies between samples taken simultaneously at the same station but differing in depth by only a few metres. He finds, for example, at the surface on station 1 a total concentration of iodine of 41·3 μgm./litre and a concentration of iodide of 15·8 μgm./litre, whereas at 10 m. the total iodine is 41·4 μgm./litre

but the iodide 18·0 μgm./litre. The lowest value for the eddy diffusion coefficient in Kuroshio water is given[2] as 7 gm. cm.$^{-1}$ sec.$^{-1}$; whence, in the absence of known biological accumulators of iodate, it would appear that, to achieve or maintain this difference, at least some 7 per cent of the iodide in the sea there undergoes oxidation daily while a somewhat similar fraction of the oxidized form undergoes reduction. To attribute the variations solely to rapid reductive processes would be unsound, since these would lead to iodide being the sole marine form of iodine.

Secondly, in experiment *B*, where Sugawara and Terada followed the time course of the conversion of 'hypoiodite' to iodate, it was not obvious to us whether the progressive slowing of the reaction was due to an approach to equilibrium or whether it represented solely the kinetics of the forward reaction. If equilibrium is being approached, then a back reaction of iodate and iodide should occur and give hypoiodite with accompanying iodine. To examine this we have added to filtered sea water a mixture of potassium iodide and iodate (molecular ratio 5 : 1) to give a total iodine concentration of 5×10^{-4} gm. atoms/litre. One sample was kept in the light, another in the dark. After 13 days, starch solution was added; but no blue colour developed, although a test showed that $0{\cdot}08 \times 10^{-4}$ gm. atoms/l. (1 p.p.m.) iodine would have been detectable. It seems clear, therefore, that the back reaction is negligible and that Sugawara and Terada's results represent solely the forward kinetics of iodate formation. Thus their second summarizing statement is without experimental foundation. We note that their results indicate a second- or higher-order reaction with respect to 'hypoiodite'—and if even second-order kinetics persist to the thousand-fold greater dilution at which iodine occurs naturally in sea water, then not more than 1–2 per cent of 'hypoiodite' would be dismuted to give iodate annually.

If the several observations are sound and to be reconciled, it seems that there remains to be uncovered some unrecognized process or compound involving iodine at concentrations of about 10^{-7} *M* in sea water.

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Are Tektites Extra-Solar-System Meteorites?

Recent communications to *Nature*[1] indicate that the origin of tektites is still a mystery. New evidence supporting an extra-terrestrial origin has been obtained by Ehmann and me[2]; we have found radionuclides induced by cosmic rays (aluminium-26 and beryllium-10) in some tektites (australites and Libyan Desert silica-glass) at levels comparable to those observed in stone meteorites and considerably above any conceivable levels of production by cosmic or terrestrial radiations at or beneath the Earth's surface. This finding practically eliminates not only the Earth, but also the Moon, as the source of tektites, since the bulk of lunar material expelled in collisions of giant meteorites with the Moon[1] would undoubtedly originate at depths of at least several metres, where the cosmic radiation would be negligible in intensity. Although these findings require confirmation and more adequate controls, it will be assumed in the following that tektites are glass meteorites from outside the terrestrial system.

The best defined fields of tektites range in size from approximately 53 km. × 130 km. for the Libyan Desert silica-glass to about 2,000 km. × 3,000 km. for the australites[3]. These areas are much greater than those occupied by the fragments of meteorites forming meteorite showers, indicating that the tektites of a given occurrence cannot be fragments of a single meteoroid which was shattered in the Earth's atmosphere. They must, then, have arrived at the Earth as a loose cluster of glassy objects.

On the other hand, in all known cases of loose clusters of small objects in the solar system (disrupted comets, meteor showers), dispersal through much greater distances than the Earth's diameter occurs in times of the order of one period or less. Urey[4] first emphasized the impossibility that self-gravitation could hold together for any appreciable time, against the disrupting influence of the Sun's gravitational field, clusters of such low density as would be necessary according to the meteoritic interpretation of tektites.

The hypothesis that the tektites have arrived as clusters of objects from outside the solar system provides a way out of these difficulties. Thus, the clusters would not have had to survive the local disruptive forces for long, and they could easily escape the regions of greatest gravitational-field gradients close to the Sun and major planets. Such a cluster of solid objects travelling through interstellar space would have collapsed into a small volume with the individuals touching one another, and a limited exposure to the disruptive forces experienced upon arrival in the solar system may explain the low density of the cluster on arrival at the Earth. The Earth's own gravitational field may be significant or even sufficient in this respect.

Using available data[3] to estimate the probable mass before fall in an individual tektite occurrence, it can be calculated roughly that, if tightly packed, about one-quarter would be strongly irradiated by cosmic rays, another one-fifth would receive moderate irradiation, and the rest would be effectively shielded. The extent of exposure would be even greater if the aggregate were loosely packed and irregular in shape. Thus an appreciable fraction of the objects should contain significant levels of induced radioactivities at the time of fall. Moreover, there should be variations in level of activity from specimen to specimen and probably regional variations over the tektite fields, so that experimental testing of the compact-cluster hypothesis is possible.

An extra-solar-system origin of tektites may also be subject to experimental verification, through isotopic analysis of the constituent elements. In view of the apparently widespread occurrence in the universe of synthesis or modification of elements, of the apparent variety of processes participating in this activity, and of the apparently continuing level of such activity[5], it is quite likely that matter formed elsewhere than our own may have different isotopic composition of some or many of its elements. Even if the processes were the same, if the times were different there would be differences in the abundances of the shorter-lived primary natural radionuclides (especially uranium-235 and potassium-40); and some extra-solar-system matter should contain locally extinct radionuclides

of shorter life-time (such as curium-247, plutonium-244, uranium-236, lead-205, samarium-146, iodine-129, etc.).

H. Suess[6], from considerations similar to the above (though not regarding the tektites to be of different origin from the meteorites in general), measured the specific potassium-40 radioactivity of potassium from several tektites and meteorites. None of the samples differed significantly from terrestrial potassium, leading to the presumption that the elements in tektites and meteorites were formed by the same mechanism and at the same time as those of the Earth. However, the measurements were of low precision and gave no information on the ratio of stable isotopes. Altogether, very little is known about the isotopic composition of the elements in tektites, which may constitute our first and only accessible samples of matter from outside the solar system. Burbidge *et al.*[5] point out the decisive importance for problems of stellar nucleogenesis of information on the isotopic composition of elements from other parts of the universe.

A non-solar-system nature of tektites would lessen the difficulty of explaining their failure to fit into the system comprising the recognized types of meteorites. Moreover, it opens for speculation (and experimental testing) a wide variety of possible origins not possible under the restrictive assumption that they are members of the solar system.

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Behaviour of the Present Sunspot Cycle

THIS communication deals with the sunspot numbers during the years 1944–57, and gives a forecast for the years 1958 and 1959. It is part of a research on the behaviour of sunspots since 1863 that will be published in due course.

Monthly and annual averages of sunspot numbers have no heliophysical meaning, because the month and the year have nothing to do with the Sun. The only acceptable average is that based upon the solar rotation with its synodical period of 27·2753 days (see, for example, Nautical Almanac, 1958). It must be remarked, however, that this figure is not as accurate as is suggested by the four decimal places, since the Sun's rotation is variable, depending upon the heliographic latitude. This value has, however, been adopted in order to link the present results with this average solar rotation. For the whole period from 1899 to March 1958, running 27·275-day averages have been calculated, in such a way that the difference between the calculated day and the theoretical one never exceeded one day.

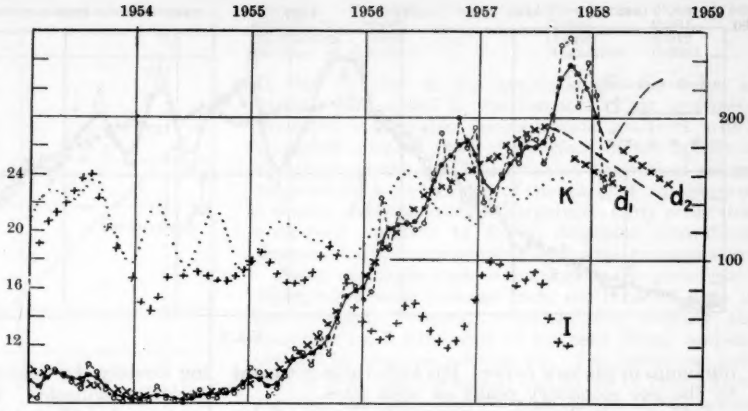

Fig. 1

Waldmeier's method of smoothing through 13 months (applied for the first time by Wolf in 1872) is not adequate, 13 months being too long. In the present investigation the smoothing method $(R_1 + 2R_2 + R_3) : 4$ has been applied. In this way a new row of figures is obtained and the same procedure may be applied again and so on. Hence smoothed rows based upon 4, 5 and more original figures are obtained. This has been continued with up to five original R's, which gives quite acceptable results. These are represented by the formula:

$$R_m = (R_1 + 4R_2 + 6R_3 + 4R_4 + R_5) : 16$$

If the values obtained are compared with those of Waldmeier the advantages of the method used are obvious.

Figs. 1 and 2 contain the following curves: a, the average value of R for each rotation of the Sun, at the first day of the rotation; b, the smoothed curve R_m; c, the smoothed monthly values of Waldmeier; d_1 and d_2, two of Waldmeier's predictions, for October 1957 and March 1958; K, the smoothed magnetic character figures after Bartels for Witteveen (Netherlands); I, the smoothed ionospheric index for De Bilt (Netherlands).

The curve b shows an outstanding series of secondary waves, especially in the neighbourhood of the sunspot maxima. This feature is common to all sunspot cycles investigated hitherto. The amplitudes are large enough to be statistically significant. The curve c, Waldmeier's smoothed curve, is obviously inaccurate; its secondary waves, 1948–50, are definitely opposite to those of curve b, a feature obvious in all sunspot cycles investigated. This behaviour is caused by the factor mentioned above: the epoch of Waldmeier's extremes is strongly influenced by the long interval of 13 months. Waldmeier has especially emphasized a secondary maximum of 148·5 in October 1948. It coincides with a

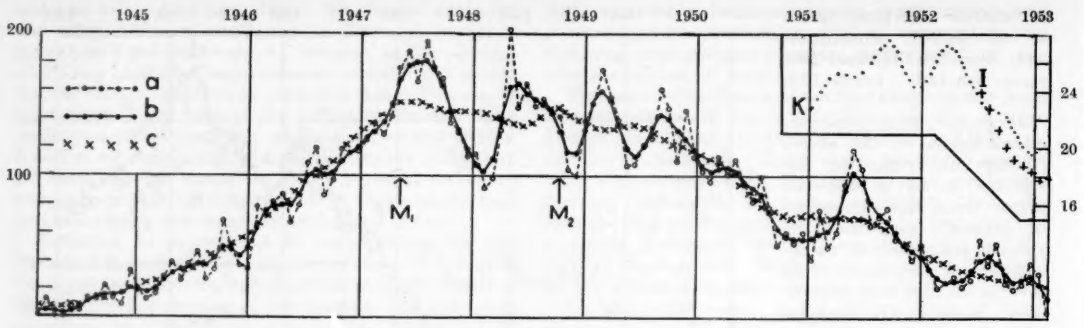

Fig. 2

minimum in the new curve. His high value is caused by the two secondary peaks on both sides.

Each month Waldmeier gives a prediction of his smoothed values of R for the coming half year. Two of these predictions have been plotted in Fig. 1 (d_1 and d_2). His maximum was in August 1957, with a smoothed value of 193·9. Without violating his curve it may be continued just between his two rows of predicted points.

The maximum of the new curve was reached in October 1957. The first secondary maximum may be expected about June to August 1958. A minimum in the rotational average was reached in March 1958; the sunspots then rose again, passing 300 at the end of March. The second secondary maximum must follow in the first half of 1959. It should be emphasized, however, that neither the heights nor the epochs of these maxima can be fixed exactly.

As regards the magnetic character, K, and the ionospheric index, I, calculated in the same way as the curve b, their course is fairly independent of the sunspot curve. During the whole of the rapid rise of the sunspot curve in 1957 both K and I were pretty well constant. Apparently both phenomena depend upon the occurrence of solar eruptions which do not by any means run parallel to the sunspots.

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Direct Measurement of the Velocity of Propagation of a Ferromagnetic Domain Boundary in 'Perminvar'

Measurements of the velocity of propagation of a ferromagnetic domain boundary were first carried out in the well-known experiment of Sixtus and Tonks[1]. Afterwards, Williams *et al.*[2] were able to measure the velocity of a single domain wall observed to exist in a [100] 'picture frame' single crystal of 3·5 per cent silicon-iron. These measurements were later extended to ferrite single crystals[3] and to polycrystalline 65 per cent nickel–iron made pseudo-single crystalline by annealing in a magnetic field[4].

All these measurements are indirect in so far as they are obtained by applying a sudden change in field and recording the value of dB/dt from the e.m.f. induced in a secondary coil. The wall velocity is then determined from the observed maximum value of the dB/dt pulse (or its integrated value) and the domain geometry as observed under static conditions by Bitter patterns.

Using a modification of the Kerr magneto-optic effect described by us[5], we have succeeded in measuring directly the velocity of the domain wall in magnetically annealed 'Perminvar' (composition, per cent: nickel 45, iron 30, cobalt 25) kindly supplied by the Post Office Research Station, Dollis Hill, London, in the form of an annular ring 1 in. external and 3/16 in. internal diameter and 147 microns thick. Observations using the Kerr effect showed that a large part of the total change in magnetization took place by radial movement of a single circular wall from the inside edge outwards. The modification of the original apparatus consists simply in using a double slit instead of a single slit as the source of illumination, focused so as to give on the surface of the specimen a light probe consisting of two rectangular images separated by a distance of 1·45 mm. The reflected light was received by a photomultiplier after transmission through a single-layer 'Polaroid'. The light intensity incident upon the photocathode then changes suddenly as the wall moves across the two images forming the light probe, and the photomultiplier output is observed on an oscilloscope as a double step. Using single-sweep operation with a calibrated time-base, the oscilloscope traces were photographed and the time taken for the wall to pass across the light probe was calculated. Fig. 1 shows a typical output trace.

A complete set of measurements in which the velocity of the wall ranges from 0·2 to 80 cm./sec. is shown in Fig. 2. For small driving fields the velocity obeys the relation:

$$V = G(H - H_c)$$

in which H_c is a critical field-strength necessary to maintain movement of the domain wall. H_c was

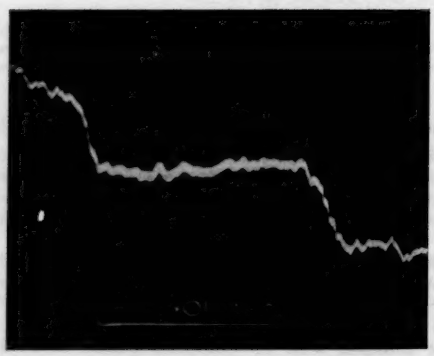

Fig. 1

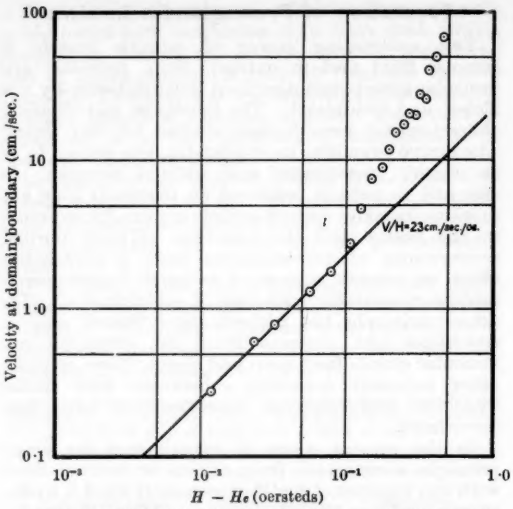

Fig. 2. Velocity of the domain boundary as a function of the excess field. The value of the excess field decreases from the inside of the specimen outwards, and H is the field at a point midway between the double light probe. The measurements are not corrected for this variation of the field

found to be 0·108 oersted. In the theoretical approximation in which the wall remains plane and relaxation effects are ignored :

$$G = \frac{\pi\rho F}{128 I_s d}$$

in which I_s is the spontaneous magnetization, ρ the electrical resistivity, d the thickness of the specimen and F is a numerical factor equal to 1·06 for a specimen of the dimensions used here. Taking $I_s = 1{,}200$ gauss, $\rho = 1{\cdot}86 \times 10^4$ e.m.u., the calculated value of G is 27 cm./sec./oersted, which agrees well with the measured initial slope of the V *vs.* $(H - H_c)$ curve, namely, 23 cm./sec./oersted. The very small discrepancy between these two values, which may be due to the neglect of relaxation effects, indicates that the velocity of the domain wall is limited almost entirely by eddy currents.

It is proposed to extend these experiments, and a fuller account will be given later.

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Aluminium Nitride Precipitates in α-Iron

An investigation which we have carried out provides more detailed information concerning the morphology of aluminium nitride precipitates formed in an α-iron matrix than that recently reported by Hsiao[1].

We employed a vacuum-melted alloy containing 1 per cent aluminium (ingot *U* of the Sloman and Evans aluminium deoxidation series[2]) made by adding 1 per cent of aluminium and 0·5 per cent of oxygen to iron of composition :

Carbon	0·0045 per cent	Phosphorus	0·004 per cent
Silicon	0·002 ,,	Nickel	0·001 ,,
Manganese	0·002 ,,	Copper	0·012 ,,
Sulphur	0·0048 ,,	Magnesium	0·0005 ,,

It was nitrided in dry ammonia gas for 5 hr. at 640° C. and cooled in the furnace. This treatment produced a nitrogen concentration gradient which extended inwards from the surface of the specimen for about 0·035 in. Examination by optical microscope of the inner portion of the nitrided zone showed a poorly resolved, mottled structure. (Any areas that contained colonies of finely dispersed aluminium oxide inclusions were avoided during the examination.)

Using the single etch extraction replica technique[3], precipitates were isolated from the nitrided zone in dry-stripped 'Formvar' replicas after etching the specimen for 3 min. with 10 per cent 'Nital' and examined by electron microscopy. The innermost portion of this zone contained two types of precipitate, namely, (*a*) long, narrow rods about 0·05μ across and up to about 4μ in length, and (*b*) small angular particles up to about 0·1μ across (Fig. 1). The method of selected area transmission electron diffraction available with a Metropolitan-Vickers type *EM3* electron microscope enabled patterns to be recorded from each type separately. In both

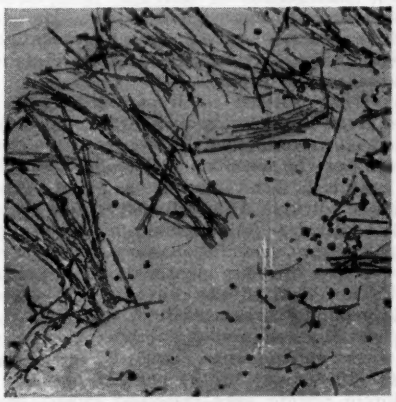

Fig. 1. Rod-like and angular aluminium nitride precipitates isolated from a nitrided iron – 1 per cent aluminium alloy in a 'Formvar' extraction replica. Electron micrograph, × 8,000

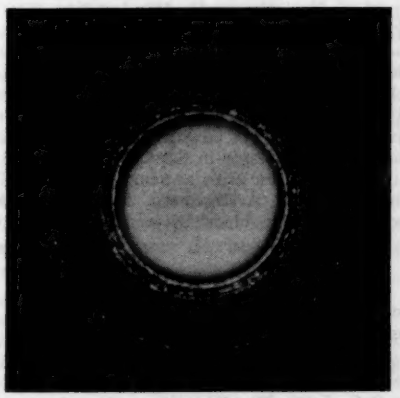

Fig. 2. Aluminium nitride transmission electron diffraction pattern obtained from both types of precipitate shown in Fig. 1

Table 1

Observations			Data for aluminium nitride*	
Ring diameter (cm.)	Corresponding d (A.)	Relative strength	d (A.)	Relative strength
2·59	2·71	S	2·70	90
2·80	2·50	M	2·49	80
2·95	2·38	M	2·36	90
3·84	1·83	MW	1·83	50
4·52	1·56	M	1·56	100
4·99	1·41	MW	1·42	100
5·20	1·35	MW	1·35	40
5·30	1·33	MW	1·33	100
5·40	1·30	MW	1·31	70
5·96	1·18	W	1·19	50

* ASTM X-ray Data Card No. 3-1144.

instances, the full aluminium nitride (AlN) pattern was obtained (Fig. 2 and Table 1). No additional lines were present.

A similar examination of areas within the mottled zone nearer the surface, and therefore having a higher nitrogen content, revealed a dense array of rod-like precipitates, finer than those shown in Fig. 1, that again gave electron diffraction patterns wholly characteristic of aluminium nitride. No angular particles were present.

These observations suggest that rod-like particles are the characteristic form of precipitation of aluminium nitride in an α-iron matrix. Unless there is interference from other elements present, this is also likely to be the characteristic form of aluminium nitride occurring in steels.

Hsiao[1] has isolated small particles up to 0·08μ across in a 'Formvar' replica dry-stripped from a nitrided steel containing 0·035 per cent aluminium after etching the specimen surface for about 15 sec. with 1 per cent 'Nital', and has assumed them to be aluminium nitride. Although they appear somewhat similar to the type (*b*) aluminium nitride precipitates of Fig. 1, other considerations suggest that they may not have been correctly identified. Thus, neither the rod-like nor the angular form of the aluminium nitride precipitates isolated from the nitrided iron – 1 per cent aluminium alloy exhibited signs of attack after severe etching with 'Nital', whereas Hsiao[1] has reported that many of the particles reputed to be aluminium nitride were dissolved during the mild 'Nital' etch given to effect isolation. The uncertainty associated with Hsiao's identification of the extracted particles could, however, be resolved if transmission electron diffraction studies were made directly on the particles in the extraction replica instead of inferring their identity from reflexion electron diffraction studies made on the etched metal section.

The information given above relating to the morphology of aluminium nitride precipitates was briefly reported at the annual conference of the Electron Microscopy Group of the Institute of Physics held at Bangor in September 1957. A fuller account of the work is to appear elsewhere. Thanks are due to Mr. R. A. Hacking, director of research, for permission to publish this communication.

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Formation of Prostaglandin *in vitro*

The contracting power of smooth muscle in seminal fluid and in extracts from prostatic and vesicular glands was described independently by von Euler[1] and Goldblatt[2]. The biological and chemical characteristics were further studied by von Euler[3]. The active principle, prostaglandin, was shown to be an organic, unsaturated acid without nitrogen. *In vivo* and *in vitro* it produced an increased tone and motility in many smooth muscle organs, for example, in the uterus and the intestine. Highly purified preparations of prostaglandin have a contracting effect on smooth muscle of isolated duodenums of rabbits comparable with that of acetylcholine[4]. The active principle has hitherto been found only in secretions and extracts from the prostatic and vesicular glands from man and sheep. More recently, other naturally occurring substances with similar biological and chemical characteristics have been described[5].

In the present series of experiments the active principle is extracted from organs or seminal fluids with two volumes of acidified acetone (1 ml. 3 *N* hydrochloric acid per 100 ml. acetone). After evaporation of the acetone under reduced pressure, the active factor is extracted from the aqueous phase by shaking thoroughly with ethyl acetate at a *p*H less than 3. The factor is then extracted by shaking vigorously with 0·15 *M* phosphate buffer at a *p*H greater than 7·5.

Biological assay was performed on the isolated, atropinized duodenums of rabbits in a 15 ml. organ-bath. The Tyrode solution was aerated with 6·5 per cent carbon dioxide in oxygen. Most of the preparations were also tested by rabbit's blood pressure. One unit per litre of bath fluid gives a definite effect on the isolated duodenum of the rabbit. Prostatic glands from man and vesicular glands from sheep contain about 3–5 units prostaglandin per gm. of organ. Seminal fluid, however, contains 30–50 units prostaglandin per ml. In the first experiments seminal fluid was left standing at room temperature; this caused no change in the content of prostaglandin. In a second series of experiments the vesicular glands from sheep were homogenized in two volumes (v/w) of 0·15 *M* phosphate buffer at *p*H 7·15. The homogenate was incubated at 38° C. with continuous shaking for varying periods. The reaction was stopped by adding two volumes (v/v) of acidified acetone and the active factor was then extracted as above. In these experiments 1 gm. of organ yielded up to 50 units prostaglandin (Fig. 1).

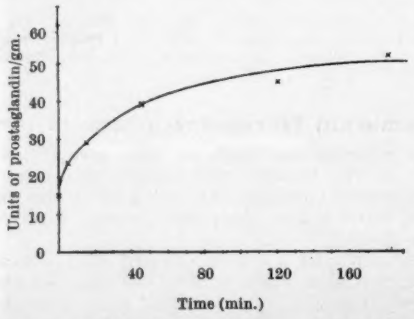

Fig. 1. Vesicular gland from sheep. Homogenized and incubated in 0·15 *M* phosphate buffer at *p*H 7·15. Temperature, 38° C.

Vogt[6] has shown that when lecithin from egg yolk is incubated with lecithinase *A*, a fatty acid, with a contracting action on smooth muscle resembling that of prostaglandin, is split off from the lecithin molecule. Francioli[7] has demonstrated lecithinases in prostatic glands of different species. The effect of lecithinase *A* on the formation of prostaglandin *in vitro* was therefore tested.

As source of the enzyme, venom from *Naja naja* (cobra) was used. 10 μgm. of venom per ml. buffer in an incubation experiment similar to that described above increased the formation of prostaglandin (Table 1).

It is known that the histamine liberator 48/80 releases not only histamine but also a slowly reacting substance[8]. When 48/80 was used in the prostaglandin experiments, however, it definitely inhibited the formation of prostaglandin (Table 1).

Table 1. Effect of Incubation on Prostaglandin Content of Vesicular Gland of Sheep. Organs Homogenized and Incubated at 38° C. in 0·15 *M* Phosphate Buffer at *p*H 7·15

Substances added	Units of prostaglandin per gm. gland		
	Non-incubated	Incubated 1 hr.	Incubated 2 hr.
Without addition	2·5	25	40
Cobra venom, 10 μgm./ml.		60	80
48/80, 10 μgm./ml.		15	20

Thus prostaglandin can be liberated from the vesicular gland of sheep in amounts which correspond to that found in seminal plasma. This formation can be enhanced by lecithinase *A*, and inhibited by 48/80. The reactions involved in the formation of prostaglandin are under investigation and will be published elsewhere.

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Potassium Atractylate, a New Inhibitor of the Tricarboxylic Acid Cycle

The roots of *Atractylis gummifera*, a Mediterranean member of the Compositae called "masticogna" in Sicily and "musciurida" in Sardinia, contain potassium atractylate, which is a glycoside the aglycone of which is not yet chemically known though it can be obtained in crystalline form[1].

The pharmacological properties of the roots of *Atractylis gummifera*, called *Camaeleon niger*, were well known in classical times and are referred to in Dioscorides' "De Materia Medica". These therapeutic properties have been almost completely forgotten, however[2]. We have recently been engaged in testing the pharmacological activity of potassium atractylate[3].

In the present communication the results of investigations carried out in animals are summarized. Potassium atractylate injected into mice, rats, rabbits and dogs at first causes hyperglycæmia (until the reserves of glycogen in the liver and muscles are exhausted), then hypoglycæmia with typical convulsions, acidosis (probably by increasing the concentration of lactic acid in the blood), and diminished oxygen consumption.

The sensitivity of the animals to the toxic action of the drug undergoes seasonal variations; thus 5 mgm./kgm. body-weight injected intravenously is sufficient in winter to kill a dog, whereas in summer a dose 4–5 times larger is necessary.

Convulsions disappear after administration of glucose, but the animals die in a state of deep depression, even after administration of bicarbonate in order to prevent acidosis. Thus, the metabolic block seems to be irreversible. The resynthesis of the glycogen of liver and muscles is inhibited, whereas the glycogen content of the heart is either not modified or is even increased.

Potassium atractylate seems to act at the level of the tissues, since it diminishes the oxygen consumption and inhibits the synthesis of glycogen by the isolated rat diaphragm and since oxidation of liver homogenate is inhibited by very low concentrations ($3·5 \times 10^{-6}$ *M*) of the drug. It is probable that potassium atractylate inhibits selectively the tricarboxylic acid cycle as it reduces the oxygen consumption of the isolated mitochondria at the same rate as it does in the homogenate. A strong inhibition of the synthesis of adenosine triphosphate has also been demonstrated directly by chromatographic determination.

It seems to be important to point out that the rate of oxidation of pyruvic and ketoglutaric acids is more depressed than that of oxalacetic acid, and that the uptake of phosphate is much more depressed than might be expected from the corresponding depression of oxygen consumption (in the oxidation of ketoglutarate in the presence of potassium atractylate the ratio phosphorus/oxygen is 0·86).

It seems likely that in the inhibition of the tricarboxylic acid cycle by atractylate, the systems regulating oxidative decarboxylation and phosphorylation are particularly involved.

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Intracellular Changes in Levels of Polarographically Active Sulphydryl Groups in Rat Liver during Carcinogenesis

The relationship of SH- and SS-groups to growth processes has been the subject of much research[1]. An increase in the concentration of SH-groups was usually associated with the mechanism of mitosis[2]. Since the observations of Hammett[3] and Voegtlin[4] the relatively high rate of cell division in tumours has been reported to be connected with greater amounts of glutathione in malignant tissue. Measurements

Table 1. Polarographic Test for Reduced Glutathione in Homogenized Liver during Carcinogenesis

These results refer to height (cm.) of polarographic anodic wave ($2GSH \rightarrow GSSG + H_2$) as shown directly in the homogenate containing approximately 100×10^6 units of deoxyribonucleic acid ($0{\cdot}5$ mgm./cm.[3])*. '*LKB*-Blomgren' polarograph, type 3266, attached to Leeds Northrup automatic recorder ('Speedomax' type *G*). Sensitivity: 10 m.amp. for full deflexion of the galvanometer. 1 cm. = 66 μgm. GSH in 1 ml.

Tissue	Normal liver	Liver fed basal diet		Liver fed 3′-methyl, 4-dimethyl aminoazobenzene								Novikoff hepatoma
Time (days)		30	180	30	60	80	100	110	150	180	210	
Value (cm.)	10·8 (5 determ.)	9·9	8·4	11·9	12·0	11·0	7·0	5·4	3·8	4·0	2·56	1·84 (5 determ.)

* DNA unit = DNA content of diploid rat nucleus = 5×10^{-12} gm. 100×10^6 DNA units = $0{\cdot}5 \times 10^{-3}$ gm.

by Greenstein of the glutathione content of spontaneous and transplantable hepatomas indicated values some 10 per cent and 24 per cent lower than those of normal liver on a wet-weight basis[5].

Work performed recently in this laboratory was concerned with the question whether there are any consistent changes in the level of free, non-protein, sulphydryl groups during the 200-day period needed for development of liver tumours in Sprague–Dawley rats fed with the carcinogenic azo-dye, 3′-methyl, 4-dimethyl aminoazobenzene ($0{\cdot}6$ per cent in a basal diet poor in riboflavin). The polarographic method was chosen because it allows ready observation and recording of changes in SH-compounds. Two tests were used: anodic oxidation of reduced glutathione ($2\,GSH \rightarrow GSSG + H_2$), which gives an anodic wave at a potential[6] of $+0{\cdot}5$ V. and can be used directly in the homogenate under nitrogen[7], and, second, Brdička's catalytic increase of cathodic current which occurs in presence of cobaltous and cobaltic ions in ammoniacal solutions. In the latter test the non-protein SH- and SS-groups give this reaction only in solutions of bivalent cobalt, while the protein-bound group gives the reaction, appearing as a characteristic 'double wave', in ammoniacal solutions of both bivalent and trivalent cobalt[8].

The application of the first test has shown that there is no change in the level of free reduced glutathione in the homogenate for approximately 80 days when the results are expressed per unit of deoxyribonucleic acid (5×10^{-12} gm.). Then there occurs a rather sudden drop in the level of reduced glutathione which falls to only 20 per cent of the original in developed hepatoma and only 10 per cent in transplantable Novikoff's hepatoma of the rat (Table 1). The sudden drop in the level of reduced glutathione after 100 days seems to coincide with that critical period of carcinogenesis when the anaerobic glycolysis suddenly starts to increase[9].

The second test was applied to the deproteinized (in an equal volume of 10 per cent sulphosalicylic acid) supernatant (1 hr. at 59,000*g*) after diluting the original homogenate to a 10 per cent suspension with sucrose. In this test a remarkable increase in the catalytic current with one single high maximum was evident in a few weeks after initiation of feeding with the carcinogenic azo-dye. This effect persisted during the whole period of carcinogenesis up to the development of gross tumours in the liver. Fig. 1 illustrates this effect in a sample prepared from liver about 40 days after the start of feeding with the carcinogen. The effect in the experimental sample disappeared if it was preincubated with 1×10^{-3} *M* iodoacetic acid for 30 min. at room temperature in slightly alkaline solution.

These polarographic observations indicate a striking change in the distribution of free SH-groups during liver carcinogenesis which may have important implications: an 'early' effect, which follows fixation of the carcinogen to protein and persists through the whole period of carcinogenesis, is manifest in the increase of sulphydryl groups; and a 'late' effect, which seems to coincide with the onset of malignant transformation and is manifest in a sudden decrease in free sulphydryl groups. Whether these effects belong to different SH-compounds or both are due to reduced glutathione in different states remains to be elucidated. It also remains to be shown whether changes in SH-levels occur in carcinogenic processes induced by other carcinogens outside the liver.

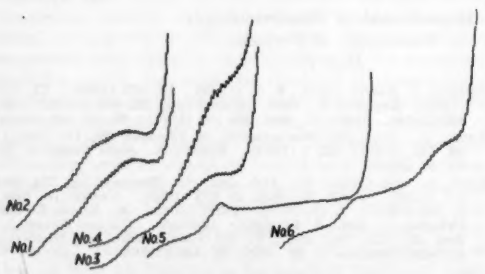

Fig. 1. Effect of the carcinogen 3′-methyl, 4-dimethyl aminoazobenzene (40 days) on free SH-groups in the supernatant of rat liver. (1) Control (basal diet) and (2) experimental, $0{\cdot}2$ ml. supernatant (dilution 1 : 10) added to 5 ml. Brdička's solution containing $0{\cdot}1$ *N* ammonium hydroxide, $0{\cdot}1$ *N* ammonium chloride and 5×10^{-4} *M* luteocobaltichloride. No polarographically detectable difference in sulphydryl content of undenatured soluble proteins.

(3) Control and (4) experimental, as for curves 1 and 2, but Brdička's solution contains bivalent cobalt ($CoCl_2.6H_2O$) instead of trivalent cobalt. Experimental sample shows increase of non-protein SH-groups.

(5) Control and (6) experimental. The effect in the experimental sample remains after deproteinization. Dilution by the deproteinizing agent is responsible for apparent decrease of catalytic reaction in comparison with curve 4. Sensitivity: 100 m.amp. for full deflexion

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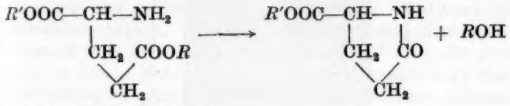
Carbon Dioxide Catalysis of the Formation of Pyroglutamic Acid

GLUTAMIC ACID and its esters and salts have a tendency to form α-pyrrolidone derivatives[1] by lactam formation:



(R,R' = H, Ca, Alkyl)

The cyclization can be brought about by heating. A strong catalytic effect of ammonia has been recorded[2].

Our experiments have revealed that carbon dioxide has a marked catalytic effect on the cyclization reaction. Dimethylglutamate is stable in dioxane at 25° C. in the absence of carbon dioxide for periods of several weeks. On saturation with carbon dioxide, however, fast cyclization occurs with a half-life of approximately 10 hr. The course of the reaction can be followed by potentiometric titration of the free amino-groups.

The reaction is of second order with respect to the amino-groups belonging to the uncyclized substance. If, however, an amine is added, which is more basic than the glutamic ester itself (for example, hexylamine), the reaction becomes of first order with respect to glutamic amine. The presence of weaker amines (for example, aniline) or tertiary amines does not change either the rate or the order of the reaction.

The order of reaction does not depend on carbon dioxide pressure, all second-order plots falling on straight lines. The dependence of the overall rate on the pressure of carbon dioxide is shown in Fig. 1. The values of k and n can be determined from the slope and intercept in the log–log plot. For dimethylglutamate at 25° C. in dioxane $n = 1{\cdot}01 \pm 0{\cdot}03$ and $k = 0{\cdot}63$ l. mole^{-1} atm.$^{-1}$ hr.$^{-1}$.

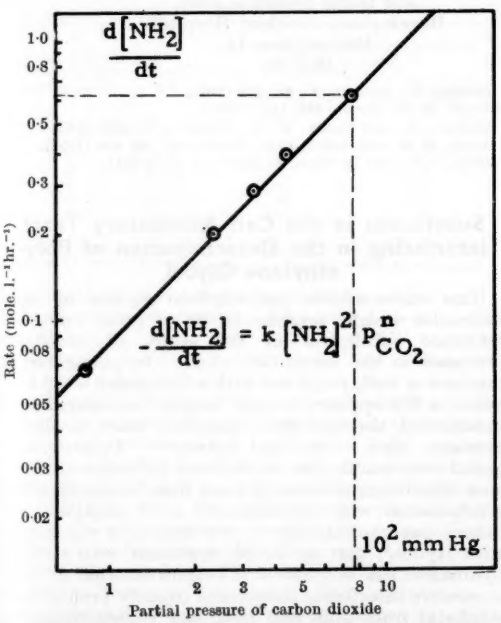
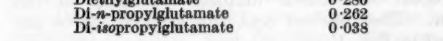


Fig. 1. The order with respect to carbon dioxide and the rate constant (k) can be determined from the plot of log(rate) vs. log(p_{CO_2}). For dimethylglutamate in dioxane at 25° C., $k = 0{\cdot}63$ l. mole^{-1} atm.$^{-1}$ hr.$^{-1}$; $n = 1{\cdot}01 \pm 0{\cdot}03$

On the basis of this evidence it can be concluded that carbon dioxide catalysed cyclization of the γ-esters of glutamic acid involves the formation of carbamates:



and that it is the carbamate salt which is the reactive species. (For a similar mechanism in condensations of α-amino-acids see ref. 3.) A weak base (aniline) will not be able to fix carbon dioxide.

In the series of glutamic diesters a marked influence of the nature of the γ-ester group is observed. The cyclization products of the diesters were all identified as the corresponding esters of pyroglutamic acid. The rate constants at 25° C. and 720 mm. mercury partial pressure of carbon dioxide are:

Dimethylglutamate	$k = 0{\cdot}600$ mole.l.$^{-1}$hr.$^{-1}$
Diethylglutamate	0·280
Di-*n*-propylglutamate	0·262
Di-*iso*propylglutamate	0·038

These findings have an important bearing on the polymerization of the Leuchs anhydride of γ-esters of glutamic acid. Oligopeptides of γ-benzylglutamate in dioxane lose their amino end-groups rapidly in presence of carbon dioxide, and there is some evidence that the rate of cyclization increases with the molecular weight of the peptide. It is important to notice that during the polymerization of Leuchs anhydrides the solution is saturated with carbon dioxide, and therefore the occurrence of a termination is probable, mainly in the initial part of polymerization, when the rate of growth of the chains is low and the concentration of amino-groups is high[4]. The cyclization reaction, therefore, has an effect on the molecular-weight distribution of the resulting polymer, tending to increase the polydispersity.

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Isolation of the α_2-Globulin Pattern on Starch Gel

ZONE electrophoresis of serum proteins in starch gels was first described by Smithies[1], who employed a borate buffer system and silver electrodes. Poulik[2] described a discontinuous system using *tris* (trihydroxymethylamino-methane) and borate buffers for the separation of proteins. Two-dimensional electrophoresis on paper, and then on starch gel as used by Smithies and Poulik[3,4], revealed at least six molecular size-groups in the α_2-globulin group. A modification of this method is described, which utilizes the combination of haptoglobins with hæmoglobin to give a faintly coloured band as visual

marker of the α_2-region and thus avoids staining. Commercially available starch is used as supporting medium, and provides a wide separation of the individual fractions.

The first electrophoresis was carried out on a strip of Whatman paper No. 3*MM*, 14 cm. wide, applying 0·1 ml. serum over 3 cm. Approximately 0·005 ml. of a hæmoglobin solution—about 5 gm. per cent—was then added to 0·2 ml. of the same serum, and 0·1 ml. of this serum was applied to the same paper 2 cm. distant. The buffer was veronal, 0·06 *M*, and the tank was that described by Flynn and de Mayo[4,5]. Using a current of 0·2 m.amp./cm. width, the length of the run was 11·5 cm. after 17 hr. The addition of the hæmoglobin solution made the identification of the α_2-region possible without staining, because the haptoglobins of the group combined with hæmoglobin and became faintly coloured. The excess hæmoglobin superimposed on the β-globulins and the edge nearest the anode defined the limit of the α_2-region. The marked and the stained strips are compared in Fig. 1.

The starch gel was prepared from Hopkin and Williams's soluble starch (analytical reagent grade) at a concentration of 12·5 gm./100 ml. in 0·01 *M tris* adjusted to *p*H 8·5 with saturated aqueous citric acid. 10 ml. of glycerol were added to 240 ml. of buffer. The gel was poured into glass trays, 20·5 cm. × 20·5 cm., and allowed to set in the refrigerator for 30 min. The electrode compartments contained each 250 ml. 0·3 *M* borate buffer, *p*H 8·6. The wet α_2-region of the paper strip was subdivided into four strips, each 5 mm. wide, which were pressed together and inserted in the cut of a 4-cm. razor blade at a distance of 7 cm. from the cathode end. Whole serum was inserted similarly, applying 0·02 ml. to a strip of cellulose acetate, 4 cm. × 5 mm. A small amount of *tris* buffer was applied to the surface of the strips and the excess blotted off. The bridges consisted of two sections of surgical lint, 21 cm. × 10 cm., moistened with borate buffer. The voltage was applied from a power-pack giving 305 V. on load. The current started at 1·7 m.amp./cm. width and finished after 2 hr. at 2·7 m.amp. The block became perceptibly warm and was cooled for 5 min. in the refrigerator and then cut and stained as usual. Three batches—Nos. 40054, 40055 and 44874—of analytical grade of starch were employed, giving closely comparable results. Fig. 2 shows a typical electrophoresis pattern for serum and the corresponding pattern for α_2-globulins.

Fig. 1. Paper electrophoresis: left, positions of β- and α_2-globulins marked with hæmoglobin; right, stained with naphthalene black

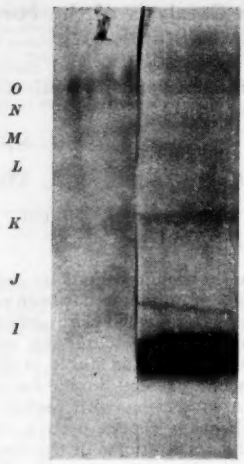

Fig. 2. Starch gel electrophoresis: left, fractions of α_2-globulins; right, whole serum. Legend as Smithies, refs. 1, 3. (*x* is an artefact)

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Substances in the Calf Alimentary Tract interfering in the Determination of Polyethylene Glycol

The water-soluble polyethylene glycols of high molecular weight promise to be of great value as reference substances in the study of exchange processes in the alimentary canal. In particular, a mixture of such polymers with a molecular weight of about 4,000 appears to pass largely unchanged and unabsorbed through the alimentary tract in sheep, humans, hens, cows and calves[1,2]. Polyethylene glycol can readily be determined turbidimetrically, once interfering substances have been removed, after precipitation with trichloracetic acid solution containing barium chloride[2,3]. We found, in agreement with Hydén[3], that an initial treatment with barium hydroxide, zinc sulphate and barium chloride sufficed to remove interfering substances (mainly protein and sulphate) from milk and from calf rumen contents, urine and fæces extracts. The method failed, however, in two respects when it was applied to samples from fistulæ in the small intestines of milk-fed calves.

(1) The filtrates obtained from samples taken from the cæcal end of the small intestine after treatment with barium hydroxide/zinc sulphate/barium chloride contained a factor which inhibited the formation of the normal polyethylene glycol suspension on the addition of trichloracetic acid/barium chloride solution. Polyethylene glycol added to such filtrates was recovered to an extent of only 50 per cent or less. Nothing is known of the nature of the interfering substance, but it was removed on adding lead acetate to the sample made alkaline with barium hydroxide.

(2) Similar filtrates from samples obtained from fistulæ a few cm. below the junction of the abomasum and duodenum gave a strong turbidity with trichloracetic acid/barium chloride solution in the absence of polyethylene glycol. The effect was particularly marked in samples taken a few hours after feeding, and neutralization of acid in the samples with more barium hydroxide gave no improvement. The filtrate gave a pink reaction with the biuret test, and it seems probable that the interfering factor was degraded protein produced in the abomasum.

Of many metallic ion treatments tried, the only one which successfully precipitated this protein was that in which mercuric chloride was added to the sample, previously made alkaline with barium hydroxide, to give a final *p*H of about 9–10·5. At a higher final *p*H all the protein was not removed; at a lower *p*H (that is, in the presence of excess mercuric chloride) some of the polyethylene glycol was precipitated (Table 1). The mixture obtained by this procedure was difficult to filter. Moreover, the interfering factor in the contents of the cæcal end of the small intestine was not removed. Both these objections are overcome by the preliminary step in the following procedure.

Table 1

Mercuric chloride (2·7 per cent) added (ml.)	Final *p*H	Estimated polyethylene glycol in sample (p.p.m.)	
		1,000 p.p.m. polyethylene glycol added	No polyethylene glycol added
1·3	11·56	1,110	120
1·7	10·75	1,030	10
1·8	10·05	1,000	< 10
2·0	9·30	1,010	< 10
2·2	8·95	1,010	< 10
2·6	8·60	850	< 10

Sample from abomasal end of small intestine. Procedure as described in text except that different amounts of mercuric chloride were used.

The contents of the small intestine are centrifuged and 2 ml. of the supernatant fluid added to a small flask with 2 ml. water and 3 ml. of 0·3 *N* barium hydroxide. 1·5 ml. of 6·6 per cent lead acetate is added slowly and followed by 1·5 ml. of 5 per cent zinc sulphate. The mixture is filtered and 5 ml. of the slightly cloudy filtrate added to another flask with 1·5 ml. water and 1·5 ml. of 0·3 *N* barium hydroxide. To this is added, a drop at a time while shaking, 2 ml. of 2·7 per cent mercuric chloride to give a final *p*H of 9–10·5. (The concentration of the mercuric chloride solution may have to be modified slightly, depending upon the other reagents and the acidity of the samples.) The mixture is filtered, and an unknown mercuric compound which is otherwise slowly precipitated from solution is removed by the addition of one drop of 5 *N* ammonium hydroxide and a further filtration. Polyethylene glycol can be determined in the filtrate in the usual way[2]. The mean recovery of polyethylene glycol added to eleven samples from different parts of the small intestine was 101·4 per cent (standard deviation: ± 0·3 per cent).

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Effect of Thyroxin Administration on the Rate and Steric Course of Enzymatic Reduction of Steroids

A necessary step in the enzymatic inactivation of Δ^4-3-ketosteroids, for example hydrocortisone, is the reduction of ring *A*[1,2]. Evidence that this process may be accelerated in thyrotoxicosis in man has been presented by Levin[3] and Peterson[4]. Because of this, the influence of thyroxin administration on the enzymatic reactions involved in the reduction was studied.

50-gm. male Sprague–Dawley rats injected daily, intraperitoneally, with 0·5 μmol. of L-thyroxin were used in the following experiments. They were killed by decapitation; livers were excised and homogenized with 2 vol. of 0·25 *M* sucrose at 0° C. Liver homogenates from rats treated as few as three days with thyroxin showed an increased ability to reduce cortisone (Table 1, col. 2). Usually little or no reducing activity was detected in liver homogenates from control rats. However, when an excess of reduced triphosphopyridine nucleotide or a system generating it was added to this incubation mixture, the results in Table 1, col. 3 were obtained. This indicated that (*a*) the rate of steroid reduction was limited by reduced triphosphopyridine nucleotide in both rat liver homogenates, and (*b*) the difference in activity between the homogenates from the thyroxin-treated and control rat was abolished by reduced triphosphopyridine nucleotide, from which one could infer the greater availability of the nucleotide for this reduction in the treated animal.

When injections were continued for a minimum of 17 days, it was found, as shown in Table 1, cols. 4 and 5, that the difference in activity could no longer be abolished by adding an excess of reduced triphosphopyridine nucleotide, and although the activities of both preparations were greatly stimulated by the added nucleotide, the homogenate from the treated animal was still approximately twice as active as the control. When the livers were fractionated by differential centrifugation[5], the increase in activity in the thyroxin-treated animal was found in the micro-

Table 1. Rate of Reduction of the 4–5 Double Bond of Cortisone by Liver Homogenates
(mμmoles cortisone reduced/min./gm. liver)

	Treated 3 days		Treated 17 days	
	Without TPNH	With TPNH	Without TPNH	With TPNH
Control	7	198	10	233
Thyroxin-treated	34	207	43	449

Liver homogenates were incubated at 37° in air with cortisone, with and without a reduced triphosphopyridine nucleotide-generating system composed of excess triphosphopyridine nucleotide, isocitric acid, isocitric acid dehydrogenase and magnesium chloride. Aliquots were removed before incubation and at 5 min., extracted with dichloromethane, the optical density of which was determined at 240 μmol. The loss of absorbance at 5 min. is expressed as μmoles cortisone metabolized/min./gm. of liver.

Table 2. Rate of Reduction of the 4–5 Double Bond of Cortisone by Cell Fractions
(mμmoles cortisone reduced/min./gm. liver)

	Control	Treated with thyroxin for 70 days
Crude homogenate	121	415
Mitochondria	6	0
Microsomes	5	174
Soluble	93	90

Experiment performed as described in Table 1 in the presence of a reduced triphosphopyridine nucleotide-generating system. Mitochondria and microsomes were prepared by a modification of the method described by Hogeboom (ref. 5). Mitochondria were washed five times and microsomes twice with 0·25 *M* sucrose. The soluble fraction was the supernatant from centrifugation of crude homogenate at 120,000*g* for 90 min.

somal fraction alone (Table 2). This increase in activity was not accompanied by an increase in the number of microsomes (judged turbidimetrically) or microsomal nitrogen.

Paper chromatography[6] of the steroids resulting from the incubation of cortisone and reduced triphosphopyridine nucleotide with microsomes from treated and untreated animals demonstrated three blue tetrazolium-reducing compounds with the mobilities of 3α- and 3β-hydroxy-5α-tetrahydrocortisone and 5α-dihydrocortisone. The reduction of Δ^4-3-ketosteroids to 5α-dihydrosteroids by microsomes and reduced triphosphopyridine nucleotide has been described by Forchielli[7]. The reaction of cortisone and reduced triphosphopyridine nucleotide with the soluble fraction obtained from treated and untreated animals produced only one blue tetrazolium-reducing compound, 3α-hydroxy-5β-tetrahydrocortisone. This has previously been described as the product of cortisone reduction catalyzed by soluble enzymes of the normal rat liver[3,4].

Thus there are two effects of thyroxin on the rate of cortisone reduction: an early increase in available reduced triphosphopyridine nucleotide, and, following prolonged treatment, an increase in the activity of a microsomal enzyme catalysing the reduction of the 4–5 double bond of ring *A*. This enhanced microsomal activity results in an increase in the production of the 5α isomer. Since the soluble enzyme producing the 5β-dihydrosteroid is not affected by this treatment, there would result an increase in the ratio of the 5α to 5β isomers. This is consistent with the findings of Bradlow *et al.*[8], who reported a shift in urinary metabolites of carbon-14 testosterone from the 5β to the 5α series following the administration of triiodothyronine to humans.

The effects described here with cortisone as a substrate have also been seen with other Δ^4-3-ketosteroids (hydrocortisone, deoxycorticosterone, Δ^4-androstene-3-17-dione, testosterone, corticosterone).

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Secretion of Androgens by the Adrenal Cortex of the Mouse

The transitory inner cortical *X*-zone of the virgin female mouse first described and illustrated by Masui and Tamura[1] and later by Howard-Miller[2], Deanesly[3] and many others, regresses rapidly during the first pregnancy and only gradually in the unmated female. It is unaffected by ovariectomy. A similar zone disappears in the male mouse before maturity but persists or redevelops after immature or adult castration. In the normal male, therefore, endogenous androgens cause regression of the zone and in both the castrated male and the virgin female exogenous androgens have the same effect[4,5]. Only androgens among purified hormones do this, so it is generally agreed that male hormones must circulate in the pregnant mouse. Jones concludes[6], after a long series of investigations, that these androgens are derived from the ovaries under the stimulation of placental gonadotrophins. The present experiments show, however, that *X*-zone regression can be stimulated in the ovariectomized unmated female or in the castrated male by subcutaneous injections of adrenocorticotrophic hormone, indicating that androgens are produced by the adrenals themselves.

Eleven virgin mice ovariectomized at 20 gm. were injected either at once or a few days after the operation with Armour's 'Acthar', 4 units twice daily for 4, 5 or 10 days, and were killed on the following day, except for two mice which were killed 6 days later. Two other mice received 4 units once daily for 10 days. In these thirteen experimental animals the *X*-zone had disappeared or was in the final stages of regression in ten and in the other three it showed hyperæmia and stages characteristic of earlier degeneration. Three control ovariectomized mice had well-developed adrenal *X*-zones. Similar experiments in twelve normal virgin mice gave similar results; in eleven the *X*-zone had regressed completely or was in the last stages of regression and in the other it had half degenerated. The reproductive organs in this group showed no indications of gonadotrophic stimulation. Out of seven normal controls the adrenal *X*-zone was intact in all except two, which showed very early stages of degeneration.

Male mice were castrated at 10 gm. and given adrenocorticotrophic hormone 4–6 weeks later when the *X*-zone was well developed, resembling the one in the virgin female. The results were similar, but rather larger or more effective doses of adrenocorticotrophic hormone were necessary for complete *X*-zone regression than in the females. Of the first seven mice receiving 5 units of adrenocorticotrophic hormone (Organon) in beeswax and oil daily for 5 days, or 8 units in gelatine daily for 5 days, only four showed partial regression of the *X*-zone. If injections of 'Acthar' (Armour) were continued for 9–10 days, however, the *X*-zone disappeared in seven of the eight mice, the remaining mouse having died on the fourth day, showing the cortical enlargement and hyperæmia which precede the degeneration of the *X*-zone. One other mouse received only 4 units daily of adrenocorticotrophic hormone (Organon) in beeswax and oil, and on the eleventh day, when it was killed, the adrenal was markedly stimulated. Not only had the *X*-zone regressed, but also in this and in four other injected mice the seminal vesicles and prostate showed tubular enlargement and glandular activity as compared with those of the castrate

controls—a further indication of the presence of male hormone.

Androgens are excreted by the ovariectomized rabbit and by the pregnant ewe, monkey and cow[7]. In the monkey and cow there is evidence that they are derived from the adrenal cortex. It may be concluded that normal regression of the *X*-zone in the mouse is due to an increase in androgen secretion during pregnancy from the adrenal cortex itself such as has been found in other mammals, and is not caused by ovarian androgens, as maintained by Jones[6].

I am indebted to Dr. D. M. V. Parrott for advice on the administration of adrenocorticotrophic hormone.

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Calcium and Magnesium Content of Normal Human Blood Serum

THERE is some 20 per cent difference between the mean values reported, from statistically significant numbers, for calcium, and a wide range of difference for magnesium in normal human blood serum (Table 1). It would thus appear that some, at least, of the methods currently used for the determination of these two cations in serum yield erroneous values. Indeed, until the advent of metal indicators, all so-called clinical methods for determining both calcium and magnesium were open to question.

It would appear that the ashing of whole serum is a necessary step in assessing the value of any method for determining the total calcium or magnesium in it. The literature, however, is significantly wanting in this respect, perhaps because the recovery of the metals from dry ashing procedures in silica crucibles is difficult and uncertain, and the use of platinum is precluded as it reacts with the metal indicator 'Eriochrome black *T*". When wet-ashing methods are used, the ubiquity of calcium and magnesium makes reagent blanks a major consideration, especially with micro-methods. Hence the importance of the observation of Middleton and Stuckey[5] that tissue organic matter can be destroyed in a flat-bottomed vessel on a hot plate at about 320° C. by repeated treatment with concentrated nitric acid which can readily be distilled free from metals.

With the method already described[4] for the micro-determination of calcium and magnesium, 0·25 ml. of serum is adequate for duplicate titrations of both metals. This amount, with 0·1 ml. of nitric acid, in a small 'volumetric' shaped 'Pyrex' flask with a flat (and level) bottom, diameter 3 cm., height 6 cm., stem 1 cm. in diameter and 3·5 cm. long, and capacity to the top of bulb about 8 ml., is gently evaporated to near dryness and then transferred to a hot plate

Table 1. CALCIUM AND MAGNESIUM CONTENT OF NORMAL HUMAN BLOOD SERUM.
(mgm./100 ml. serum)

Reference	Method	No. of sera	Calcium: Mean	Calcium: Range	Magnesium: Mean	Magnesium: Range
1	Spectrographic	86	8·6	6·1–10·5	—	—
2	Removal of calcium with oxalate and protein with trichloracetic acid. Colorimetry with 'Eriochrome black *T*'	103	—	—	1·90	1·21–2·54
3	Whole serum with murexide solution titrated with ethylenediamine tetraacetic acid	24	—	—	2·10	1·75–2·50
3	Oxalate–permanganate	710	9·7	8·9–10·5	—	—
4	Flame spectrophotometric	712	10·5	9·7–11·3	—	—
4	Oxalate–permanganate	22	10·8	—	—	—
This work	Removal of protein by *p*H adjustment and heat (ref. 7) and colorimetry as described (ref. 6)	22	10·4	—	—	—
		34	9·5	8·8–10·4	2·03	1·80–2·30

at about 320° C. for 10–15 min. The flask is cooled, 0·1 ml. of nitric acid is again added, it is brought to near dryness and the flask is then transferred to the plate at 320° C. The ash may be white—indicating the complete destruction of the organic matter—at this stage but a third treatment is usual. To the dry ash is now added 2·5 ml. of 0·1 *N* nitric acid. The flask with contents is weighed, set on a hot plate to boil gently for about 10 min., reweighed, and the loss made up by addition of deionized water. From this test solution, 0·5-ml. portions are used for the determination of calcium with murexide as indicator, and 0·2-ml. portions for the determination of magnesium plus calcium with 'Eriochrome black *T*" as indicator.

By this method calcium and magnesium added to serum have been precisely recovered, even in the presence of phosphate added up to 40 mgm./100 ml. serum.

The formation of complexes with the indicators by such trace metals in serum ash as copper, zinc, manganese and iron is considered to be negligible.

In Table 2 the analyses of the ash of thirteen sera from hospital patients, carried out as described above, are set alongside those obtained by the same analytical method from deproteinized serum filtrates prepared as previously described[7]. The close agreement of the two methods shows that suitably deproteinized serum filtrates yield true values for calcium and magnesium and renders the rather tedious ashing procedure unnecessary for routine purposes.

The oxalate–permanganate method commonly used in hospitals for the determination of calcium on 2-ml.

Table 2. CALCIUM AND MAGNESIUM DETERMINED ON SOLUTIONS OF THIRTEEN ASHED HOSPITAL SERA AND ON THEIR CORRESPONDING DEPROTEINIZED FILTRATES
(mgm./100 ml. serum)

	Calcium: Ash	Calcium: Filtrate	Magnesium: Ash	Magnesium: Filtrate
Mean	9·02	9·05	1·98	1·99
Range	7·9–10·0	8·0–9·9	1·80–2·25	1·80–2·20

serum samples gives values, on the present evidence, about 10 per cent too high. Nine sera from hospital patients were examined by both methods with the following results: oxalate method, mean 10·3, range 9·9–10·9 mgm./100 ml.; murexide method, mean 9·2, range 8·8–9·6 mgm./100 ml.

I am indebted to Dr. A. Preston, Oxford Regional Transfusion Service, for the normal bloods reported in Table 1. This work is part of a programme in the development of methods for the study of the blood-cerebrospinal fluid barrier in association with Dr. H. V. Smith, May reader in medicine in the University of Oxford, and is made possible by a grant from the Nuffield Foundation.

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Tolerance of Skin Homografts related to Fatal Disease in Separated Rat Parabionts

Homotransplantation of viable tissue in adult individuals is possible only between identical or monozygotic twins. Successful homografting between dizygotic calves is due to anastomoses of placental vessels[1]. However, tolerance to homografts may be artificially induced[2] if animals are exposed to foreign tissue antigens during fœtal life. The upper limit of the period of tolerant response varies in different species but never extends far beyond birth[3]. In rats[4] tolerance may be induced as late as the second week of life.

In all these cases some form of parabiosis had existed and played the essential part in conferring tolerance. In an attempt to extend still further the 'adaptive' period it seemed justified to use parabiosis as a procedure of choice and see whether tolerance could be conferred at a more advanced stage of development, perhaps even in adult animals.

122 albino rats of both sexes, weighing 80–180 gm. (age, 5–13 weeks) and belonging to two unrelated random-bred strains, *Y* and *W*, were used; donor and recipient always belonged to a different strain and were of the same weight and sex. 38 animals were tested for compatibility with free full-thickness skin grafts; no graft survived beyond the twelfth day (mean survival time $W \rightarrow Y$, $8{\cdot}1 \pm 0{\cdot}4$ days; $Y \rightarrow W$, $10{\cdot}2 \pm 0{\cdot}4$ days; $0{\cdot}001 < P < 0{\cdot}01$). 84 animals were put in parabiotic union[5], making a total of 42 pairs; a tubed pedicle was formed from the dorsal lip of the skin wound in the donor and its distal free end sutured into a defect on the back of the recipient. Ether anæsthesia combined with urethane (100 mgm. per 100 gm. body-weight) was used throughout. The animals were separated on the fifth post-operative day; the tubed pedicle was ligatured and cut as near the graft as possible.

Results are presented in Table 1. Twenty-five separated hosts (59·5 per cent) completely destroyed their grafts by the tenth post-operative day. Eleven recipients (26·2 per cent) carrying viable grafts appeared at first to be healthy; suddenly, between the eighth and the twenty-fifth post-operative day, the animals became ill and died from within a few hours to a couple of days from the onset of the disease. The illness sometimes followed a more protracted course, the animal dying as late as the forty-third post-operative day. At time of death, the majority of grafts were fully preserved, showing good growth of hair. In some cases there was an initial necrosis of superficial epidermal layers, but that was as far as the immune reaction of the host could go except in two cases where grafts were considerably reduced in size. Regeneration took place only from graft. The best preserved part of the graft was always that farthest from the remnant of the tubed pedicle.

Table 1. Fate of Grafts, Number of Recipients (with percentages in brackets)

Graft destroyed by the tenth day	Graft viable at time of host's death	Prolonged survival of graft	Alive with viable graft	Total
25 (59·5)	11 (26·2)	5 (11·9)	1 (2·4)	42 (100)

These 11 hosts are shown in Table 2. The cause of death was severe anæmia, pulmonary œdema and sometimes inanition. Post-mortem examination revealed atrophy of lymph glands with almost complete disappearance of thymus. The spleen and adrenals were usually enlarged. *Bartonella* parasites were not found. The incidence of disease was evenly distributed between the two strains and sexes. Five more hosts (11·9 per cent) recovered and destroyed their grafts between the fifteenth and the twentieth post-operative day. One host (2·4 per cent), a female weighing 170 gm., also recovered and is still in a good condition 72 days after the operation, carrying a partly preserved graft. This animal was challenged with a graft from the third strain on the eighteenth post-operative day. This it destroyed completely 13 days later. This very limited trial shows that a graft could be made tolerant of its host too, and that tolerance in these cases might be strain-specific.

The disease described herein strikingly resembles and is probably identical with the so-called 'parabiotic disease'[5]. The same might be true of conditions recently described in mice[6] and chicks[7]. Parabiotic disease is a very common occurrence in permanent parabiosis between genetically unrelated partners, and in our experience appears in one of the parabionts between the seventh and thirteenth post-operative days. The animal usually dies in a few days but may recover if separated from its partner sufficiently early (unpublished work). The graft and its host could be considered as two distinct animals and, though

Table 2. Incidence of Disease as related to Sex, Weight and Strain Combination; Onset of Disease and Survival Times of Tolerant Hosts*

Sex	Initial weight (gm.)	Strain combination	Onset of disease (days after operation)	Died (days after operation)	Condition of graft at time of death†
♂	80	$W \rightarrow Y$	11	13	f.p.
♂	80	$Y \rightarrow W$	12	13	p.p.
♀	90	$Y \rightarrow W$	10	10	w.p.
♂	100	$Y \rightarrow W$	9	11	w.p.
♀	100	$W \rightarrow Y$	15	19	w.p.
♀	110	$Y \rightarrow W$	17	17	f.p.
♂	120	$W \rightarrow Y$	13	17	w.p.
♀	130	$W \rightarrow Y$	9	16	f.p.
♀	145	$Y \rightarrow W$	25	43	p.p.
♂	160	$Y \rightarrow W$	8	10	f.p.
♂	160	$W \rightarrow Y$	16	31	f.p.

* Data refer to eleven recipients from Table 1, col. 2.
† f.p., fully preserved graft; w.p., well preserved graft; p.p., partly preserved graft.

tolerated, the graft always remains an intruder. It is not surprising, therefore, that the graft and its host could behave as true parabionts. During parabiotic union, the graft connected with donor via pedicle could be conditioned to produce a much greater quantity of antibodies against its host than a free graft could. However, the graft may not be the only source of antibodies. Adult blood cells can survive and perhaps even multiply in embryos and newly born animals[6,7]. It is not impossible that some of the adult cells, exchanged in enormous numbers as soon as cross-circulation is established on the fourth day of parabiotic union, may also survive and form antibodies against their host.

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Effect of Oxy-chlororaphin on the Growth *in vitro* of *Streptomyces* Species and Some Pathogenic Fungi

During the course of other investigations, oxy-chlororaphin was found to inhibit strongly the growth of *Streptomyces* sp. 441. Chlororaphin (melting point 225° C. in nitrogen) was separated directly by centrifuging a five-day-old submerged culture of *Pseudomonas aeruginosa* containing glycerol (Sierra, G., and Veringa, H. A., unpublished work). Yields as great as 0·53 gm./l. were obtained (considerably greater than the yield of 5–16 mgm./l. obtained from a 14-day-old glucose culture at 28° C. by Birkofer[1]). Crystalline oxy-chlororaphin was obtained by dissolving chlororaphin in acetone (discarding the insoluble fraction). After cooling in contact with the air, the solution yielded crystals of oxy-chlororaphin. Several recrystallizations in acetone were necessary to obtain the pure compound (melting point 242° C.).

The activity tests were made by the usual method. Oxy-chlororaphin was incorporated into suitable agar media in an appropriate range of graded concentrations. The medium used was Sabouraud's glucose-agar, consisting of 0·5 per cent glucose, 2 per cent agar and 1·5 per cent 'Bacto-peptone' (Difco), the *p*H being adjusted to 5·6–5·8. *Streptomyces* cultures were incubated at 25° C. and cultures of pathogenic fungi at 37° C.

Manometric experiments show that a concentration of oxi-chlororaphin (333 parts per million) much higher than that necessary to inhibit completely the growth of *Candida albicans* in Sabouraud's glucose-agar medium does not affect the rate of uptake of oxygen from Sabouraud glucose by washed suspensions of this fungus. Oxy-chlororaphin (333 parts per million) does not affect the auto-respiration of *Candida albicans* in phosphate buffer (*p*H 6·4).

Table 1. Effect of the Oxy-chlororaphin on the Growth of Some Pathogenic Fungi and *Actinomycetes*
The fungi were obtained from the Centraalbureau voor Schimmelcultures, Baarn, Holland; the *Actinomycetes* were from local stock

Cultures tested	Concentration of oxy-chlororaphin giving inhibition (parts/million)	
	Complete	Partial
Trichophyton mentagrophytes	12·5	6·3
Epidermophyton floccosum	25·0	12·5
Candida albicans	50·0	12·5
Microsporum audouini	25·0	12·5
Blastomyces dermatitidis	25·0	12·5
Streptomyces 404	25·0	6·3
Streptomyces 411	12·5	6·3
Estreptomyces 421	25·0	6·3
Streptomyces A. 425	25·0	6·3

No ill effects were observed in mice (weighing 20 gm.) injected intraperitoneally with 10 mgm. oxy-chlororaphin suspended in olive oil.

The action of oxy-chlororaphin certainly cannot be that of an antiseptic, in that it does not act as a general protoplasmic poison interfering with the respiration. As its action is more fungistatic than fungicidal, we may assume that it has some antagonistic action by which growth is prevented. Studies are under way to elucidate further the action of this compound *in vivo*.

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A Strain of *Acetobacter aceti* giving a Positive Cellulose Reaction

A strain of *Acetobacter aceti* was isolated with many other acetic acid bacteria from ciders. It was identified by the use of Frateur's tests[1], and showed a positive cellulose reaction in addition to the usual characteristics of *A. aceti*, namely, catalase production, growth in Hoyer's medium, production of dihydroxyacetone from glycerol and gluconic acid from glucose. After staining the growth with iodine, and applying sulphuric acid, a blue colour developed. This reaction occurred slowly, and within 1–2 hr. the preparation appeared green. Microscopic examination revealed the presence of a non-cellular material which was blue in colour, intermingled with bacterial cells stained yellow by the iodine. The colour gradually intensified during the ensuing 24 hr. until the whole preparation then appeared blue.

The appearance of this organism in culture was quite unlike that of a typical cellulose producer, such as *A. xylinum*. It did not produce a cartilaginous pellicle in liquid media nor was the growth coherent on solid media, although it could be pulled into a short slimy string when touched with an inoculating needle. Further, the strain of *A. aceti* was actively motile and has been shown to possess peritrichous flagella (J. L. Shimwell, private communication).

There is thus a considerable difference between the cultural characteristics of this particular strain of *A. aceti* and of a typical cellulose producing *Acetobacter* species. In fact, the only characteristic which suggests the presence of cellulose in this culture of

A. aceti is the blue colour given with iodine and sulphuric acid. This suggests that the iodine–sulphuric acid test may not be specific for cellulose, which is not surprising since this appears to be a traditional and empirical test the mechanism of which is not fully understood. Alternatively, it may be that the amount of cellulose produced by this particular strain of *A. aceti* is insufficient to yield a tough leathery growth. The possibility that this organism may not produce true cellulose does not, however, affect its unusual taxonomic position: the only chemical criterion used by Frateur for cellulose production is the ability of a culture to produce a blue colour in the presence of iodine and strong sulphuric acid. This would include all true cellulosic organisms and any which produce substances giving a similar colour reaction.

As Shimwell[2] has already shown, the *Acetobacter* proper (excluding Frateur's *Suboxydans* group) are particularly prone to mutation or variation, one species easily changing to another by the loss or gain of certain biochemical activities. Shimwell[2] has suggested, on the basis of these findings, that it should be possible to find organisms with combinations of characteristics additional to the species listed by Frateur[1]. This has already happened since both Dr. Shimwell[2] and I (unpublished work) have found such organisms in vinegar brewing materials and ciders respectively. The significance of this strain of *A. aceti* is that it represents one end of the mutational range with *A. paradoxum* at the other, the former having all Frateur's characteristics positive and the latter all negative. It would, therefore, only appear to be a matter of time before all the 32 'species' postulated by Shimwell[3] are discovered.

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Utilization of Thiocyanate by *Thiobacillus thioparus* and *T. thiocyanoxidans*

Two years ago we began to study whether *Thiobacillus thioparus* and *T. denitrificans* could break down thiocyanate oxidatively in the same way as *T. thiocyanoxidans*; it was immediately apparent that the former did, but since initial results suggested that the first and last of these organisms might nevertheless be separate species we decided not to publish our results at that time. All strains of *T. denitrificans* received were contaminated and since it has been our practice to work from single-cell culture we abandoned temporarily the study of *T. denitrificans*.

De Kruyff, van der Walt and Schwartz[1] have shown the capacity not only of *T. thioparus* but also of *T. denitrificans* to break down thiocyanates both aerobically and anaerobically in the presence of nitrate. They suggest that *T. thioparus* and *T. thiocyanoxidans* are one and the same organism; and with the present cultures this seems probable. The *T. thiocyanoxidans* which they studied is identical with the one we are now using, but it is not our original strain and there have been metabolic differences in the strains we have isolated from time to time. We have always accepted the view of Baalsrud[2] that the different *Thiobacilli* may perhaps represent a similar group of organisms rather than distinct species.

In the present work *T. thioparus* and *T. thiocyanoxidans* were compared for their ability to utilize both thiocyanate and thiosulphate for growth. They are grown at 30° C. on thiosulphate or thiocyanate media prepared as follows. Thiosulphate medium: 1·0 gm. sodium thiosulphate ($Na_2S_2O_3$ $5H_2O$), 0·35 gm. potassium dihydrogen phosphate, 0·14 gm. potassium hydroxide, 0·01 gm. ammonium chloride, distilled water to 100 ml. Thiocyanate medium: 0·025 gm. potassium thiocyanate, 0·35 gm. potassium dihydrogen phosphate, 0·14 gm. potassium hydroxide, 0·01 gm. ammonium chloride, distilled water to 100 ml.

After sterilizing at 15 lb./in.^{2} for 15 min. and cooling, 1·0 ml. of each of two cool, sterile salt solutions *B* and *C* were added: (*B*), 1·0 gm. magnesium sulphate ($MgSO_4.7H_2O$), 0·2 gm. anhydrous ferric chloride, 0·2 gm. manganese sulphate ($MnSO_4.4H_2O$), 3 ml. concentrated hydrochloric acid, distilled water to 100 ml. (*C*), 1 per cent calcium chloride solution. Viable cell counts were made by direct plating on thiosulphate media set with agar and by the technique of serial dilution which was slightly modified from that used in "Bacteriological Examination of Water Supplies"[3]. Thus an estimate could be made of the most probable number of cells present in a culture of each medium. To do this, five series of tenfold dilutions (10^{-2}–10^{-9}) of cultures of each organism in both types of medium were used. In preliminary experiments the values for cell population obtained from the tables of most probable number derived from the paper on "Bacteriological Examination of Water" were compared with those obtained from direct plate counts. Values so obtained were identical within the limits of error for the method employed. Results showed the infectivity of both organisms for thiocyanate and thiosulphate to be equivalent.

Organism	Substrate	Most probable number of cells/ml.
T. thioparus	Thiosulphate	$5·3 \times 10^8$
T. thioparus	Thiocyanate	$2·0 \times 10^8$
T. thiocyanoxidans	Thiosulphate	$5·2 \times 10^8$
T. thiocyanoxidans	Thiocyanate	$8·3 \times 10^8$

These results obviously suggested that *T. thioparus* had a similar or identical capacity with *T. thiocyanoxidans* for growing on thiocyanate.

As a further check on this similarity or identity of metabolic properties, several cultures of both organisms which utilized thiocyanate were back-inoculated in serial dilution into thiocyanate medium. The dilutions were 1/30, 1/900, 1/27,000, 1/810,000, etc. In two series *T. thioparus* in 1/30 dilution of the culture grew and utilized thiocyanate in these further cultures upon thiocyanate while another failed completely; whereas cultures of *T. thiocyanoxidans* could be diluted to 1/27,000 or 1/810,000 and continue to raise fresh populations of cells utilizing thiocyanate. These results disturbed the provisional conclusion that both organisms were in fact identical, but further studies were made using a modified technique. Serial dilutions were made into 5 ml. of medium (instead of 3 ml.) and incubated for 10 days, and since both organisms grow in thiosulphate these cultures were back-inoculated into both thiosulphate and

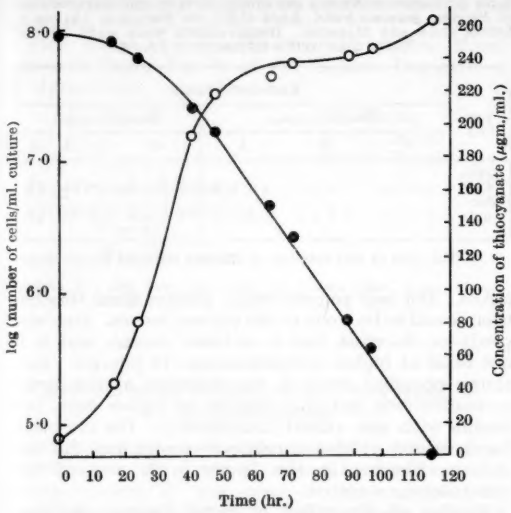

Fig. 1. Comparison of the growth of *Thiobacillus thiocyanoxidans* and its utilization of thiocyanate: ●, thiocyanate concentration (μgm./ml.); ○, log (number of cells per ml. of culture)

thiocyanate. The results were completely identical; growth occurred in thiosulphate medium throughout the whole range of dilution (1/30–1/24,300,000) and on thiocyanate medium down to a dilution of 1/810,000. Thus the identity of the present strain of *T. thiocyanoxidans* with *T. thioparus* as far as utilization of thiocyanate is concerned cannot be doubted—a result in conformity with the fuller findings of De Kruyff *et al.*

Fig. 1 represents the growth of viable cells of *T. thiocyanoxidans* with time, when the organism is grown at 30° C. in thiocyanate medium; the concurrent rate of disappearance of thiocyanate is also recorded. The viable cell population does not increase much after 48 hr. when approximately 20 per cent of the substrate has disappeared.

It should be mentioned, however, that cell autolysis seems to be rapid with this organism and there is abundant liberation of amino-acids and growth factors into the medium (including, Dr. E. Holdsworth tells us, some vitamin B_{12}) and thus many heterotrophs can grow in the supernatants which remain after the culture has apparently become sterile. We mention this fact since we do not accept the view of some distinguished workers that mass cultures of *T. thioparus* and *T. denitrificans* can be grown without careful sterilization and the resulting cells used for manometric and other studies, at least if the metabolism of these organisms are as close in metabolic properties to *T. thiocyanoxidans* as they appear to be.

Manometric experiments on the oxidation of various organic substrates by *T. thiocyanoxidans* have been carried out. Cells grown on thiosulphate medium show very little oxidation of formate or succinate, whereas cells grown on thiocyanate medium show a marked increase in the ability to oxidize both these substrates, especially in the case of formate. It has been observed that in cases where the cell suspension has a very high endogenous respiration, other substrates such as pyruvate have been oxidized. We have obtained colorimetric evidence which suggests that small amounts of formate may appear in cultures of *T. thiocyanoxidans* when growing upon thiocyanate.

We are grateful to De Kruyff *et al.* for directing our attention to the classical work of Beijerinck[4].

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The Pennatularian Genus *Umbellula*

The examination of a numerically large collection of two species of *Umbellula* from the Swedish Deep-Sea Expedition[1] implied that many of the specific criteria hitherto employed would have to be dropped. Later investigation of an interesting series of antarctic and subantarctic specimens from the *Discovery* collections, together with a revision of the collections of *Umbellula* kept in the British Museum, has confirmed this assumption.

The species of *Umbellula* vary rather extensively in external aspect according to age and development and evidently also under different ecological conditions and more or less fortuitous contractions. In the first case, however, there are two characters which by their combinations, so to say, divide the genus into four groups. Hickson[2], in accord with Kükenthal[3], emphasized the importance of the presence or absence of spicules as *fundamentum divisionis*; but in his last paper Hickson[4] discarded Kükenthal's other fundamental character, namely, a square or a round axis. Both authors seem to have overlooked the connexions between degree of calcification, finer structure of the inner parts and its relation to the anatomy of the coenosarcal layers, and the external aspect of the axis.

The structure of the spicules, too, is so characteristic that we can base two separate species on them alone: *U. durissima* has rod-shaped or feebly fusiform spicules, some of them with feebly knobbed ends; *E. thomsonii* has rod- or needle-shaped, three-flanged or -ridged spicules. The difference between the two species is further emphasized by the axis, which in *durissima* is round and almost devoid of carbonate of lime, while in *thomsonii*, on the other hand, it is quadrangular and strongly calcified.

The other and larger group of the genus is devoid of spicules. Here the axis is round in two species and all but completely devoid of carbonate of lime and extremely flexible. But the polyp clusters are distinctly different. *U. huxleyi* has rather small autozooids concentrated in a packed pompom at the end of the rachis, whereas *U. spicata* has its autozooids irregularly spread over an exceptionally long, distal, swollen part of the rachis as a long tassel.

The last two (or possibly three) species of the genus again have quadrangular axes but these are heavily encrusted with carbonate of lime. *U. pellucida* has small autozooids packed in a pompon terminally on the rachis; the entire specimens evidently do not

exceed 35 cm. in total length, and their axes are very thin and brittle as compared with all the other species. *U. lindahli* is much more robust, and in most examples its axis is remarkably flexible, despite its rather strong calcification. Fully grown specimens of this species are seldom less than 40 cm. long and have large autozooids, which, especially in colder waters, are placed in great numbers in more open tassels.

The six species mentioned are the only ones which are sufficiently described at present. Although the distribution of *U. encrinus* indicates that it is an arctic species, its structure suggests that it is only an extreme, ecological form of the cosmopolitan *U. lindahli*; this question needs further examination. A full report on the collection will appear in the "Discovery" Reports.

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Effect of Metal Ions on the Development of Wheat Stem Rust

During a study of the effect of benzimidazole, dimethylbenzimidazole, glucose and metal ions on the development of rust in detached leaves, certain metal ions have been noted to be extremely effective in the prevention of rust development in detached wheat leaves of both resistant and susceptible varieties.

Wheat seedlings at the two-leaf stage were inoculated with urediospores of *Puccinia graminis tritici* and incubated for 24 hr. in a moist chamber. At the end of incubation, the leaves were excised and floated on various solutions of metal ions in Petri plates. The development of rust was noted on the ninth day after excision of the leaves. Results of the effect of various metal ions on rust development in detached Khapli leaves are given in Table 1. Khapli leaves, normally resistant to race 15*B*–1, became susceptible after detachment when floated on water. From the results, it is evident that the rust development in these leaves is markedly checked by nickel ions even with a concentration as low as 0·5 p.p.m. Cobalt, molybdenum, copper, manganese and iron have no effect on rust development. Cobalt induces chlorosis in the leaves with concentrations of 2–4 p.p.m., and any concentration greater than this has been found to be toxic to the excised leaves. Zinc also produces chlorosis, but to a lesser extent, and it is not toxic at higher concentrations (10 p.p.m.). Zinc shows no effect on rust development at the lower concentrations and only slightly at higher ones, but results with zinc varied considerably. On the other hand, nickel yielded consistent results and did not induce chlorosis in the leaves with any of the concentrations tested.

Table 2. Effect of Nickel and Cobalt Ions on the Development of *Puccinia graminis tritici*, Race 15*B*-1, on Detached Leaves of Little Club and Marquis. Observations were made on the Ninth Day after Excision of Leaves

Variety	Rust development						
	Cobalt (p.p.m.)			Nickel (p.p.m.)			
	0	2	4	0	2	3	4
Little Club	++++	++++	++++	++++	+*	+	nil
Marquis	++++	++++	++++	++++	nil	nil	nil

* +, The type of rust reaction of attached resistant Khapli leaves.

Studies on the effect of metal ions on the rust development in detached leaves of susceptible varieties (Little Club and Marquis) were made only with cobalt and nickel. Results are given in Table 2. Cobalt shows no inhibition of rust development; on the other hand, nickel is very effective in the prevention of rust development in the detached leaves of susceptible varieties. With these varieties, a slightly higher concentration of nickel is necessary in order to obtain the same degree of inhibition as that found on Khapli leaves.

The effect of these metals on the inhibition of rust development in detached leaves does not correspond to their effect on germination and growth of urediospores of *P. graminis tritici*. For example, in descending order of effectiveness at 4 p.p.m., nickel, iron, zinc and copper inhibit both the germination and growth, cobalt inhibits growth only, having no effect on germination, whereas manganese and molybdenum have no apparent effect on either phenomena.

Sempio[1] had also shown that infection of *Puccinia triticina* was greatly reduced by adding nickel (*M*/7500) to the nutrient solution. Because of the results reported here it would be unwise to state categorically that nickel acts as a fungicide *per se*. Its effects on the host may be equally important and we have found that it has the effect of slowing down both the synthesis and breakdown of chlorophyll in uninfected detached etiolated and green leaves.

Table 1. Effect of Various Metal Ions on the Development of *Puccinia graminis tritici*, Race 15*B*-1, in Detached Khapli Leaves Observations were made on the Ninth Day after Excision of Leaves

Metal ion	Rust development								
	Concentration of metal ions (p.p.m.)								
	0	0·1	0·25	0·5	1·0	2·0	3·0	4·0	5·0
Ni^{++}	++++	+++	+	nil	nil	nil	nil	nil	nil
Zn^{++}*	++++	++++	−	++++	−	++++	−	+++	++
Co^{++}	++++	++++	−	++++	−	++++	++++	++++	toxic
Mo^{++}	++++	−	−	−	++++	−	−	++++	++++
Cu^{++}	++++	−	−	++++	−	−	−	−	++++
Mn^{++}	++++	−	−	++++	−	−	−	−	++++
Fe^{++}†	++++	−	−	−	−	++++	−	++++	++++

Key: nil, the site of rust infection appears as pin-point light-coloured spot; no further development. +, the original type of rust reaction–rust development is greatly delayed. ++, rust development is slightly checked; pustules are developed. +++, rust development is not delayed; pustules are well developed. ++++, rust development is not delayed; pustules are very well developed; sporulation is prolific.

* With 10 p.p.m. rust development gave +. † No effect was observed even with 10 p.p.m. solution.

Further studies are in progress to determine its site of action.

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Photoperiodic Induction of Flowering in Black-Currant

During the course of a detailed morphological investigation of flower-initiation in black-currant (*Ribes nigrum*) it was observed that under field conditions flower primordia are normally initiated in the axillary buds following the cessation of active extension growth of the shoot. This observation suggested that possibly flower initiation depends on the cessation of extension-growth and that treatments which bring about the latter might also induce flowering. It is known that this species grows actively under long-days but rapidly becomes dormant under short-days[1], and the following experiments were therefore carried out to test whether short-day treatment promotes flower-initiation.

Plants of the variety Baldwin raised from hardwood cuttings were allowed to grow under natural long-day conditions until they had attained a height of about 50 cm. They were then selected for uniformity and divided into three groups which were exposed to the following photoperiodic conditions, respectively: (1) 8-hr. photoperiods (29 plants); (2) 18-hr. photoperiods (19 plants); and (3) natural day-length conditions (10 plants). The treatments were commenced on June 21 and within 2–3 weeks the plants under short-day conditions were observed to have ceased extension growth. On July 29 (after 5 weeks treatment), 14 of these short-day plants were transferred back to long-days, under which conditions the axillary buds expanded in 2–3 weeks, and a high proportion of the axillaries in the upper part of the shoots produced flowers which set fruit in September. The plants maintained under long-day throughout continued active extension-growth until the experiment was terminated on September 12. At this date many of the axillary buds had elongated into short shoots which were entirely vegetative. The plants maintained under natural day-length conditions ceased extension-growth at the beginning of August and were afterwards found to have initiated flowers in the normal way.

Further experiments with plants decapitated before treatment (as part of another investigation) have confirmed these results and have indicated that a period of exposure to 16 short-days is sufficient to induce flowering, provided that fully expanded leaves are present on the plants. This latter result is directly comparable with the conditions necessary for photoperiodic induction of flowering in herbaceous plants and suggests that short-day treatment may have a direct effect on flower-initiation in black-currant, independently of any effect on extension-growth. This possibility is being further investigated.

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Effect of Number of Sprouts per Set on Yield and Grading of Main-Crop Potatoes

It is well known that the number of stems formed by a potato plant profoundly affects the size and number of tubers produced[1,2], and that some varieties tend to produce many stems and thus a high proportion of small unsaleable tubers[3]. If sprouted seed of such varieties with only one or two sprouts per set are planted, the resulting crop contains a high proportion of ware (table potatoes)[4].

In 1957 the effect of sprouted seed tubers on stem and tuber production was investigated in respect of four maincrop varieties (King Edward, Majestic, M.A.N.I. Seedling 480/51 and Ulster Supreme) in two seed sizes (mean weights 44 gm. (1½ oz.) and 80 gm. (2¾ oz.)). Three sprout treatments were used: (*a*) all but one sprout removed; (*b*) all but three sprouts removed; (*c*) multiple sprouts as grown. Spacing was standardized at 36 in. apart each way. The plants were lifted by hand and recorded individually (Tables 1 and 2).

Table 1. Mean Number of Main Stems and Tubers per Plant

Variety	Seed size	Mean No. of main stems per plant			Mean No. of tubers per plant		
		a	*b*	*c*	*a*	*b*	*c*
Majestic	*M*	1·0	2·2	2·5	11·0	14·5	17·3
Ulster Supreme	*M*	1·0	2·7	3·7	11·0	17·0	19·4
King Edward	*S*	1·0	2·7	2·9	12·3	19·0	23·4
King Edward	*L*	1·0	3·0	4·6	19·8	23·7	32·2
King Edward	*M*	1·0	2·8	3·7	16·1	21·3	27·8
M.A.N.I. 480/51	*M*	1·0	2·7	9·5	20·5	22·9	45·7

S, Small seed; *L*, large seed; *M*, mean of small and large seed.

Table 2. Mean Number of Tubers per Plant in each Grade in Treatments *a* and *c*, Seed Size Averaged

Variety	Treatment	Grade			
		1	2	3	4
Majestic	*a*	2·9	3·5	2·1	2·5
Majestic	*c*	1·5	5·5	5·3	5 0
Ulster Supreme	*a*	5·5	3·2	1·0	1·3
Ulster Supreme	*c*	2·9	7·7	5·7	3·1
King Edward	*a*	1·7	4·8	5·2	4·4
King Edward	*c*	0·7	3·5	10·4	13·2
M.A.N.I. 480/51	*a*	2·1	6·1	5·9	6·4
M.A.N.I. 480/51	*c*	0·3	4·4	11·5	29·5

Grades 1, 342 gm. (12 oz.) and greater outsize; 2, 172–341 gm. (6–12 oz.), large ware; 3, 71–171 gm. (2½–6 oz.), small ware; 4, 2–70 gm., seed and chats.

There was a wide variation in behaviour between varieties in the number of stems and tubers formed[5], and their grading. At one extreme, M.A.N.I. 480/51 formed too many stems and tubers on treatment *c* (multiple sprouts) for satisfactory ware production, yielding a mean of 9·5 stems and 45·7 tubers per plant. Up to 17 stems and 69 tubers were recorded on a single plant, such plants producing little marketable ware. On treatment *a* (single sprouts) these were reduced to 1·0 and 20·5 respectively, when this variety appeared to be a useful cropper of large red ware.

At the other extreme Majestic produced fewer stems (mean 2·5) and tubers (mean 17·3) with a low proportion of small tubers in treatment *c*. This variety rarely formed four or more stems per plant, which produced an increased number of smaller tubers. In treatment *a* the number of tubers was reduced, but there was an excessive proportion of large coarse tubers unfit for sale. The behaviour of Ulster Supreme was comparable to Majestic, and in both these varieties reducing the sprouts to one per set was unsatisfactory.

King Edward was intermediate between these extremes, but the amount of large ware was greatly increased by reducing the sprouts. Treatment *a* reduced the total number of tubers and increased the proportion of large ware. The behaviour of the two seed sizes in this treatment should be noted. Treatments *b* (large seed) and *c* (small seed) were practically identical, producing a mean of approximately three stems per set and similar numbers of tubers. Treatment *c* (large seed) tended to produce more stems and a greater number of tubers, ranging up to six stems and 43 tubers on a single plant. This treatment was unsatisfactory for ware production.

The number of stems formed per plant appeared generally to correspond to the number of sprouts per set planted, but with marked varietal differences. Considerable suppression of sprouting was noted. Varieties (King Edward and M.A.N.I. 480/51) which often produce a high proportion of small tubers benefited markedly from sprout reduction, whereas the others did not. Large seed tended to form more sprouts and stems than small seed[6,7] and a higher proportion of small tubers. Full details are reserved until it is possible to include the 1958 results, when a complete account of the work will be published.

Grateful acknowledgment is made to Mr. C. V. Dadd of the National Agricultural Advisory Service, Cambridge, for his help, to the Governors of this Institute for provision of facilities, and to the Ministry of Agriculture, Northern Ireland, for co-operation and for supplying part of the seed.

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May 29.

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Chromosome Breakage at High Radiation Dose-Rates

The variation of the frequency of chromosomal aberrations as a function of radiation dose-rate has been the subject of numerous experimental investigations, and the results of such studies have been of considerable importance in formulating theories of the basic mechanisms of radiation action[1]. With the recent availability of radiation sources of great intensity, such as electron linear accelerators, and the development of reliable dosimetric techniques for use at these intensities, the extension of studies on chromosomal breakage into the range of the extremely high dose-rates has become feasible.

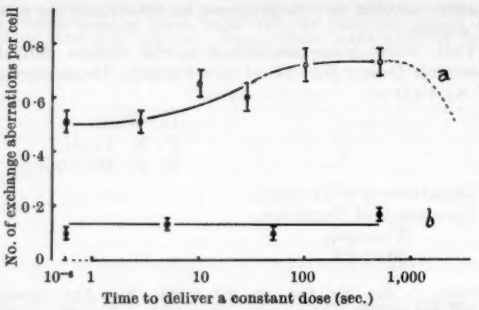

Fig. 1. Variation of the frequency of exchange aberrations with dose-rate for a constant dose of about 400 rads. *a*, In air; *b*, in nitrogen

An exploratory investigation of chromosomal breakage in microspores and pollen has been carried out at dose-rates up to 4×10^8 rads/sec. using the electron and X-ray beams from the 15-MeV. linear accelerator at St. Bartholomew's Hospital. Special ionization chambers in conjunction with 'Perspex' dosimeters[2] were used in the determination of the dose applied. The biological material has been *Tradescantia paludosa* (clone 3 of Sax), made available to us through the courtesy of Mr. George Lacour and the John Innes Horticultural Institution. Chromosome aberrations in *Tradescantia* microspores examined 4–5 days after irradiation have been studied in most of the work to date.

All results so far obtained indicate a definite and significant decrease in the frequency of aberrations at dose-rates of more than 10 rads/sec., for material irradiated in air. This decrease in the frequency of aberrations has been observed repeatedly for deletions as well as for exchange aberrations. Typical results obtained from one set of experiments are shown in Fig. 1, which relates to irradiations carried out in air and in nitrogen with 14-MeV. electrons. The dose was about 400 rads for both media. The dotted portion of the upper curve shows the expected frequencies of exchange aberrations at lower dose-rates reported by Wolff and Luippold[3]. The curve for irradiations in air shows that the frequency of exchange aberrations has a constant value over a range of medium dose-rates and falls off at both high and low dose-rates. In nitrogen neither the deletions nor the frequency of exchange aberrations decreases at high dose-rates.

At present there is no satisfactory explanation of the drop (40–50 per cent) observed at high dose-rates from the plateaux at medium dose-rates, although mechanisms involving recombination of secondary organic free radicals appear qualitatively plausible. An alternative explanation of this result based on partial temporary anoxia resulting from immediate consumption of oxygen under intense bursts of radiation has also been proposed. A preliminary experiment carried out under increased oxygen tension suggests that the second explanation may be correct.

A complete account of this work will be published elsewhere.

We wish to acknowledge financial support from the British Empire Cancer Campaign and the Treasurer and Board of Governors of St. Bartholomew's Hospital. We also wish to thank Prof. J. Rotblat,

head of the Linear Accelerator Research Unit at St. Bartholomew's Hospital, for his help and co-operation.

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Competition between Genotypes in *Drosophila melanogaster*

IT has been shown by Birch[1] that the main competitive effect in *Drosophila pseudo-obscura* is between larvæ. Lewontin[2] studied the larval viabilities of various strains of *D. melanogaster* mixed with a white-eyed stock and found that the viability of a genotype is partially dependent on the genotypes co-existing with it.

In a two-point back-cross linkage experiment, the proportion of competing genotypes is different in each phase. Considering such an experiment for two factors *a* and *b* which are somewhat inviable in the recessive state, four genotypes are obtained in the offspring:

AB/ab, *Ab/ab*, *aB/ab*, *ab/ab*

In coupling, the most and least viable genotypes, *AB/ab* and *ab/ab*, predominate in the progeny, and hence under crowded conditions there will be a tendency for elimination of *ab/ab* flies. In repulsion, *Ab/ab* and *aB/ab* predominate and the main competition is between these two genotypes. The recombinants *AB/ab* and *ab/ab* will not compete with each other to any great extent but will compete mainly with the parentals. Hence the elimination of *ab/ab* will not be as great as in coupling. Thus in very crowded conditions a difference in the viability relations can be expected between coupling and repulsion.

Using the two sex-linked genes, white (*w*) and miniature (*m*), results for coupling and repulsion (Table 1) were collected for two-point backcrosses in *D. melanogaster* for three levels of competition which can be termed low, medium and high levels. For all levels, flies were mated for 48 hr. For the low level one pair was mated in a ½-pint milk-bottle, for the medium level one pair in a small vial, and the high level six pairs in a small vial.

Assuming no competition between larvæ, the ratios *wm* : ++ and *w*+ : +*m* should not vary between coupling and repulsion. A simple contingency χ_1^2 may be done within each level to test this (Table 2).

The only significant result is for the high level where the ratio *wm* : ++ varies between coupling and repulsion. In coupling, the *wm* flies are of much poorer viability than the ++ flies, but in repulsion this is not so. The less extreme contrast, *w*+ and +*m*, does not show any variation between coupling and repulsion.

Table 1. RESULTS FOR *w–m*

		wm	*w*+	+*m*	++	Total
Low	*C*	478	236	211	483	1,408
	R	318	529	569	289	1,705
Medium	*C*	409	205	236	407	1,257
	R	190	407	424	200	1,221
High	*C*	506	288	300	659	1,753
	R	580	976	1,062	553	3,171

C, Coupling; *R*, repulsion.

Table 2. χ_1^2 TESTS FOR *wm* : ++ AND *w*+ : +*m* WITHIN EACH LEVEL OF COMPETITION

Levels	*wm* : ++		*w*+ : +*m*	
	χ_1^2	*P*	χ_1^2	*P*
Low	0·71	0·3 < *P* < 0·5	2·53	0·1 < *P* < 0·2
Medium	0·16	0·5 < *P* < 0·7	0·62	0·3 < *P* < 0·5
High	13·56	*P* < 0·001	0·18	0·5 < *P* < 0·7

This difference arises as a result of differential competition between larvæ according to the proportions of competing genotypes present. The implication of the viability of a genotype varying according to the competing genotypes has not been stressed, although Haldane[3] deals with it in an early paper. In natural conditions, where competition is much more severe than in artificial laboratory conditions, such effects must assume some importance. Thus selective advantages and disadvantages of a gene or genotype must be considered in relation to the food available, and the types and proportions of the other genotypes in the population.

Further discussion with additional results will be published elsewhere.

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May 31.

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Effects of Environment (Radiation, Substrate and Allelic Genes) on the Melezitose Gene in *Saccharomyces*

THE melezitose locus (*MZ*) in *Saccharomyces* controls the formation of the adaptive enzyme, melezitase, which acts on five substrates: turanose (*T*), maltose (*M*), sucrose (*S*), methyl-α-D-glucopyranoside (*G*), and melezitose (*Z*), each of which may serve as an inducer of melezitase[1–3]. Seven different variations (alleles) of this gene are known and are designated *TMSGZ*, *TMSGz*, *TMSgZ*, *TMSgz*, *TMsgz*, *Tmsgz* and *tmsgz*[3]. The capital letters indicate the substrates which are capable of inducing melezitase in glucose-grown cultures. Cells in which melezitase has been induced by one of the substrates to which it responds adaptively are able to split the substrates which do not act as inducers in that specific genotype without further adaptation. For example, a glucose-grown culture carrying *TMSgz* responds to neither methyl-α-D-glucopyranoside nor melezitose, but splits both these substrates after exposure to turanose, maltose or sucrose.

The first evidence of the *MZ* series came from hybridization experiments. The various genes produced by hybridization were inferred to have resulted from gene conversion in the hybrid since they were stable in the vegetative condition and arose at meiosis of heterozygotes only.

Five genes of the *MZ* series were obtained by ultra-violet radiation of *TMSGZ*. The limited kinds which were produced by gene conversion and ultra-violet radiation indicate that alterations of the gene

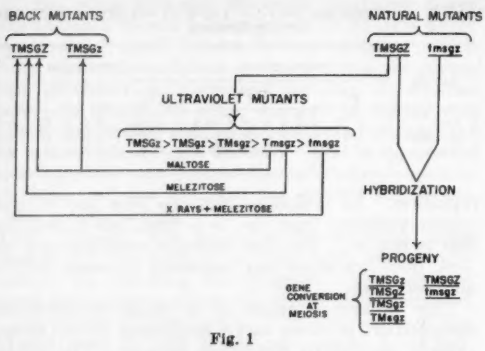

Fig. 1

occur in an orderly manner[3]. This view was further supported by the relative frequencies of the different types of mutants induced by ultra-violet radiation.

Back mutation of the gene occurred from 'recessive' to 'dominant' when the ultra-violet-induced mutants (*tmsgz* excluded) were exposed to substrate which they could not utilize. The gene *tmsgz* had proved refractory to back mutation by substrate alone (or by ultra-violet and substrate). Mutations of *tmsgz* back to *TMSGZ* were induced by the combined action of X-rays and substrate[4]. The linear mutation–dose-response curve for X-ray-melezitose induced back mutants, and the failure to detect intermediate variations of the gene indicates that the mutation from *tmsgz* to *TMSGZ* is a single event (Pittman, D., Lewis, C. H., and Lindegren, C. C., in preparation). The synergistic effect of X-rays and melezitose being necessary to induce the single event suggests that X-rays render the gene mutable and melezitose specifies the mutation. The five traits of the back mutant are transmitted as a single gene in hybrids. The cleavage-rate of melezitose by X-ray-induced back mutants was lower than that of a wild type strain, indicating that the 'new' gene was not so potent functionally as the 'original' gene.

Fig. 1 is a diagram of the various manifestations of the gene and the effect of various agents upon them. Ultra-violet radiation effects the degradation of *TMSGZ* to produce five different genes with the relative frequencies: $TMSGz > TMSgz > TMsgz > Tmsgz > tmsgz$. Each of the 'degraded' genes is characterized by the inability of the mutant to respond adaptively to one or more of the inducing substrates by the induction of the enzyme melezitase. The fact that only five of 31 possible genes are produced by ultra-violet radiation of *TMSGZ* supports the view that the degradation of the gene is an orderly process, and that the gene is limited in the number of its manifestations. The 'intermediate' genes respond to substrate alone (without the mediation of radiation) by back mutation. Back mutation of *Tmsgz* on melezitose produced only *TMSGZ* while back mutation of *Tmsgz* on maltose produced both *TMSGZ* and *TMSGZ*, indicating that substrate specifies the back mutation to a limited extent. The fact that back mutation from those induced by ultra-violet radiation can occur led to the inference that the phenotypes of the intermediate genes do not result from deletion but rather from alteration of the gene. The gene *tmsgz*, which is incapable of responding as an inducer to any of the substrates, is incapable of reverse mutation by exposure to substrate only. Although *tmsgz* cultures are refractory to back mutation when plated on the five substrates, if exposure to substrate is preceded by X-irradiation, back mutation occurs. It is inferred that X-rays and the substrate act synergistically and that X-rays render the gene mutable and substrate specifies the mutation which shall occur. In the absence of either X-rays or substrate, mutations occur at a very low rate. The X-ray-substrate back mutants are of two types—either the totipotent *TMSGZ* or $TM^{r}SG^{r}Z^{r}$, the latter being variable in their capacity to respond to the inducers maltose, methyl-α-D-glucopyranoside and melezitose. The variable mutants may be originally *TMSGZ* but may lose some recently acquired capacities rather readily. The stability of *S* may mean that a mutation at another locus (*SU*) had occurred. These variable mutants are under further investigation to determine the nature of the instability induced by radiation. The reconstituted *TMSGZ* gene is functionally less active than the original gene. These 'restorative' mutations resemble the repair of a damaged locus rather than the construction of a 'new' gene. A capacity not found in the genus might be introduced by exploitation of the combined effects of unequal crossing and the synergistic effects of substrate and radiation.

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May 15.

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Abundance of Pogonophora

A previous communication[1] reported the occurrence of Pogonophora in the Atlantic. Since then another cruise has been made on R.V. *Sarsia*, and more preserved material examined. Species of *Siboglinum* have now been taken at six stations along the continental slope between lat. 47° 56′ N., long. 7° 56′ W. and lat. 48° 32′ N., long. 10° 11′ W. at depths ranging from 300 to 710 fathoms, and specimens of at least three of them brought back alive to the laboratory. Species of the same genus have also been found in bottom samples taken by Mr. N. A. Holme in 1956 at depths of only 80–90 fathoms off Dingle Bay on the west coast of Ireland.

Clearly, these interesting relatives of the chordates must be widely distributed in communities on muddy bottoms, and not only in deep water. It is surprising that they have escaped previous notice, as the areas where they have now been found were among the first to be dredged and trawled over by marine zoologists. No doubt the superficial resemblance of the tubes to the fibres used in dredge and trawl netting has hindered earlier recognition.

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APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ZOOLOGIST (with a degree) IN THE PHYSICS DEPARTMENT to assist in studies of effects of radiation on bone—The House Governor, Westminster Hospital, London, S.W.1 (July 29).

ASSISTANT LECTURER IN SOIL PHYSICS IN THE DEPARTMENT OF AGRICULTURAL SCIENCES—The Secretary, School of Agriculture (University of Nottingham), Sutton Bonington, near Loughborough (July 31).

ASSISTANT LECTURER IN THE DEPARTMENT OF PHARMACEUTICS, and an ASSISTANT LECTURER IN THE DEPARTMENT OF PHARMACEUTICAL CHEMISTRY—Clerk to the Council, School of Pharmacy (University of London), P.O. Box 125, 29/39 Brunswick Square, London, W.C.1 (July 31).

TECHNICAL OFFICER (A.I.M.L.T. or with a science degree, competent in blood group serology, and preferably experience in plasma drying and/or fractionation) to act as Deputy to the Chief Technical Officer—The Medical Director, National Blood Transfusion Association, Pelican House, 52 Lower Leeson Street, Dublin (August 6).

RESEARCH FELLOWS IN CHEMISTRY, METALLURGY, ELECTRICAL ENGINEERING AND PHYSICS—The Registrar, College of Technology, Gosta Green, Birmingham 4 (August 7).

ASSISTANT EXPERIMENTAL OFFICER (female, with a degree in a biological subject and practical experience in bacteriological methods and techniques), for supervisory duties in media preparation and general laboratory management and to assist in experimental work on ecology of soil micro-organisms—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (August 9).

ASSISTANT LECTURER OR LECTURER IN THE DEPARTMENT OF INORGANIC AND PHYSICAL CHEMISTRY—The Registrar, The University, Liverpool (August 9).

DEMONSTRATOR IN BOTANY—The Registrar, The University, Leeds 2 (August 9).

LECTURERS or ASSISTANT LECTURERS (with an honours degree in mathematics and research experience in either pure mathematics or mathematical physics) IN MATHEMATICS—The Registrar, Manchester College of Science and Technology, Manchester 1 (August 14).

ANIMAL PHYSIOLOGIST (graduate with qualifications and research experience in physiology) at Canterbury Agricultural College, University of New Zealand, to undertake research work with animals and some lecturing duties—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (August 15).

ASSISTANT LECTURER (preferably with special interests in human geography) IN GEOGRAPHY—The Assistant Registrar, The University, Edmund Street, Birmingham 3 (August 16).

POST-DOCTORAL FELLOW (Ph.D. standard with research experience in organic chemistry) IN THE DEPARTMENT OF ORGANIC CHEMISTRY to undertake work on metabolics of marine micro-organisms—The Registrar, The University, Liverpool (August 16).

RESEARCH OFFICER (with an honours degree in science (majority in botany and plant physiology) or agricultural science, and post-graduate experience in relevant fields) IN THE PLANT AND SOILS RESEARCH LABORATORY, Division of Plant Industry, C.S.I.R.O., Brisbane, Australia, to conduct a research programme on the effects of the climatic factors of the environment on the growth and reproduction of subtropical and tropical pasture and crop plants, with particular attention to the effects of temperature and photoperiod—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 146/108 (August 16).

SENIOR LECTURERS or LECTURERS (male, with an appropriate first- or second-class honours degree and preferably teaching experience) IN MATHEMATICS (preferably Applied Mathematics), MECHANICAL ENGINEERING, ELECTRICAL ENGINEERING, RADAR AND TELECOMMUNICATIONS, and ENGINEERING PHYSICS at the Royal Military College of Science, Shrivenham, Berkshire—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A262/8A (August 18).

LECTURER IN PHILOSOPHY at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 22).

LECTURER (with at least a Master's degree in chemical engineering and some experience in the teaching of chemical engineering instrumentation) IN CHEMICAL ENGINEERING at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 22).

GEOLOGIST (with an honours degree in geology requiring a four-year course at a recognized university, and preferably previous experience) with the Southern Rhodesia Government—The Secretary (R), Rhodesia House, 429 Strand, London, W.C.2 (August 23).

CHEMISTS, SCIENTIFIC OFFICER or SENIOR SCIENTIFIC OFFICER GRADE (with a first- or second-class honours degree in chemistry or equivalent, and for Senior Scientific Officer posts, some research experience) at the Road Research Laboratory (D.S.I.R.), Harmondsworth, Middlesex, for research into the use and performance of bituminous road materials and on problems arising from the presence of organic matter in soils—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.475/8A (August 29).

DEMONSTRATOR IN THE DEPARTMENT OF BOTANY—The Registrar, The University, Nottingham (August 29).

CURATOR (preferably aged 35–40, with an honours degree in zoology) OF MAMMALS—The Secretary, Zoological Society of London, Regent's Park, London, N.W.1 (August 31).

DEMONSTRATOR IN PHYSICS—The Registrar, Trinity College, Dublin (August 31).

LECTURER (with an honours degree in chemistry and preferably experience in radiochemical techniques) IN CHEMISTRY at the University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, August 31).

ASSISTANT LECTURER IN THE DEPARTMENT OF GEOGRAPHY—The Registrar, The University, Liverpool (September 6).

LECTURER IN MICROBIOLOGY at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 8).

CHAIR OF INDUSTRIAL MICROBIOLOGY—The Secretary, University College, Dublin (October 1).

PROFESSOR OF MATHEMATICS at the University of Tasmania, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 13).

ASSISTANTS, Grade B (2) (with an honours degree in physics and an interest in some branch of applied physics) for Physics—The Clerk to the Governors, South-East Essex Technical College, Longbridge Road, Dagenham, Essex.

LABORATORY STEWARD (preferably with some knowledge of chemistry and experience of handling scientific apparatus) for Chemistry and Biology Laboratories, Coventry Technical College—The Director of Education, New Council Offices, Earl Street, Coventry.

LECTURER IN MATHEMATICS to develop courses in methods of teaching mathematics for students training to teach in Technical Colleges—The Director, Training College, Queen Street South, Huddersfield.

LECTURER IN PHYSICS, able to teach up to B.Sc. General and Grad.Inst.P. standard—The Principal, Technical College, Brunswick Road, Gloucester.

LECTURER (with a good honours degree or equivalent, together with teaching, research, or industrial experience, and able to offer specialized knowledge of a branch of applied physics) IN PHYSICS—The Clerk to the Governors, Mid-Essex Technical College and School of Art, Market Road, Chelmsford, Essex.

PRINCIPAL (with high academic qualifications and appropriate educational and administrative experience)—The Clerk to the Governing Body, Northern Polytechnic, Holloway, London, N.7.

READER IN STATISTICS—The Professor of Statistics, University of Melbourne, Carlton N.3, Victoria, Australia.

RESEARCH ASSISTANT to assist in postgraduate laboratory teaching of telecommunication, and to assist research in speech and aural perception—Dr. E. C. Cherry, Electrical Engineering Department, Imperial College, London, S.W.7.

RESEARCH ASSISTANTS IN THE DEPARTMENT OF CHEMISTRY for experimental work on the thermodynamic properties of mixtures—The Registrar, The University, Reading.

RESEARCH CHEMIST (with a first- or second-class honours degree in chemistry and preferably research experience in physical chemistry or chemical engineering), to lead a small team engaged on studying the chemical aspects of new processes and providing chemical and physical information on which chemical plant designs are to be based—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. 1912/34.

RESEARCH FELLOW or ASSISTANT (with a good scientific background and a sound knowledge of aerodynamics and preferably experience of flight research) IN THE DEPARTMENT OF FLIGHT, to assist in an expanding programme of full-scale aerodynamic research—The Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks.

SENIOR LABORATORY TECHNICIAN, Class 1, in the Biochemistry Section of the Group Pathology Service—The Group Secretary, York (A) and Tadcaster Hospital Management Committee, Bootham Park, York.

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